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TO THE

NATURAL HISTORY OF THE UNITED STATES

OF

NORTH AMERICA.

BY

L. AGASSIZ.

54/4

PART I.

ESSAY ON CLASSIFICATION.

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ESSAY ON CLASSIFICATION.

CHAPTER FIRST.

THE FUNDAMENTAL RELATIONS OF ANIMALS TO ONE ANOTHER AND TO THE WORLD IN WHICH THEY LIVE, AS THE BASIS OF THE NATURAL SYSTEM OF ANIMALS.

SECTION I.

THE LEADING FEATURES OF A NATURAL ZOÖLOGICAL SYSTEM ARE ALL FOUNDED IN NATURE.

Modern classifications of animals and plants are based upon the peculiarities of their structure, and this is generally considered as the most important, if not the only safe guide in our attempts to determine the natural relations which exist between animals. This view of the subject seems to me, however, to circumscribe the foundation of a natural system of Zoölogy and Botany within too narrow limits, to exclude from our consideration some of the most striking characteristics of the two organic kingdoms of nature, and to leave it doubtful how far the arrangement thus obtained is founded in reality, and how far it is merely the expression of our estimate of these structural differences. It has therefore appeared to me appropriate to present here a short exposition of the leading features of the animal kingdom as an introduction to the embryology of the Chelonians, one of the most extraordinary types among Vertebrata, as it would afford a desirable opportunity of establishing a standard of comparison between the changes animals undergo during their growth, and the permanent characters of full grown individuals of other types, and, perhaps, of showing also what other points beside structure might with advantage be consid-

ered in ascertaining the manifold relations of animals to one another, and to the world in which they live, upon which the natural system may be founded.

In considering these various topics, I shall of necessity have to discuss many questions bearing upon the very origin of organized beings, and to touch upon many points now under discussion among scientific men. I shall, however, avoid controversy as much as possible, and only try to render the results of my own studies and meditations in as clear a manner as I possibly can in the short space I feel justified in devoting to this subject in this volume.

There is no question in Natural History on which more diversified opinions are entertained than respecting classification; not that naturalists disagree as to the necessity of some sort of arrangement in describing animals or plants, for since nature has become the object of special studies, it has been the universal aim of all naturalists to arrange the objects of their investigations in the most natural order possible, and even Buffon, who began the publication of his great Natural History by denying the existence in nature of any thing like a system, closed his work by grouping the birds according to certain general features exhibited in common by many of them. It is true authors have differed in their estimation of the characters on which their different arrangements are founded; it is equally true that they have not viewed their arrangements in the same light, some having plainly acknowledged the artificial character of their systems, whilst others have urged theirs as the true expression of the natural relations which exist between the objects themselves. But whether systems were presented as artificial or natural, they have, to this day, been considered generally as the expression of man's understanding of natural objects, and not as a system devised by the Supreme Intelligence, and manifested in these objects.[1]

There is only one point in these innumerable systems on which all seem to meet, namely, the existence in nature of distinct species, persisting with all their peculiarities, for a time at least, for even the immutability of species has been questioned.[2] Beyond species, however, this confidence in the existence of the divisions generally admitted in zoölogical systems diminishes greatly.

With respect to genera, we find already the number of the naturalists who

[1] The expressions constantly used with reference to genera and species and the higher groups in our systems as: Mr. A. *has made* such a species *a genus;* Mr. B. *employs* this or that species to *form his genus;* and in which most naturalists indulge when speaking of *their* species, *their* genera, *their* families, *their* systems, exhibit in an unquestionable light the conviction that such groups are of their own making, which can, however, only be true in so far as these groups are not true to nature, if the views I shall present below are at all correct.

[2] LAMARCK (J. B. DE) Philosophie zoologique, Paris, 1809, 2 vols. 8vo.; 2de édit., 1830.—POWELL (THE REV. BADEN) Essays on the Spirit of the Inductive Philosophy, etc., London, 1855, 1 vol. 8vo. Compare, also, Sect. 15, below.

accept them as natural divisions much smaller, few of them having expressed a belief that genera have as distinct an existence in nature as species, and as to families, orders, classes, or any kind of higher divisions, they seem to be universally considered as convenient devices, framed with the view of facilitating the study of innumerable objects, and of grouping them in the most suitable manner. The indifference with which this part of our science is generally treated becomes unjustifiable, considering the progress which Zoölogy in general has made of late. It is a matter of consequence, whether genera are circumscribed in our systematic works within these or those limits, whether families inclose a wider or more contracted range of genera, whether such or such orders are admitted in a class, and what are the natural boundaries of classes, as well as how the classes themselves are related to one another, and whether all these groups are considered as resting upon the same foundation in nature or not.

Without venturing here upon an analysis of the various systems of Zoölogy, the prominent features of which are sufficiently exemplified for my purpose by the systems of Linnæus and Cuvier,[1] which must be familiar to every student of natural history, it is certainly a seasonable question, to ask whether the animal kingdom exhibits only those few subdivisions into orders and genera, which the Linnæan system indicates, or whether the classes differ among themselves to the extent which the system of Cuvier would lead us to suppose. Or is, after all, this complicated structure of classification merely an ingenious human invention which every one may shape as he pleases to suit himself? When we remember that all works on natural history admit some system or other of this kind, it is certainly an inquiry worthy of a true naturalist to ascertain what is the real meaning of all these divisions.

Embryology, moreover, forces the inquiry upon us at every step, as it is impossible to establish precise comparisons between the different stages of growth of young animals of any higher group, and the permanent characters of full grown individuals of other types, without ascertaining first what is the value of the divisions, with which we may have to compare embryos. This is my reason for introducing here, in a work chiefly devoted to Embryology, a subject to which I have paid the most careful attention for many years past, and for the solution of which I have made special investigations.

Before, however, I proceed any further, I would submit one case to the consideration of my reader. Suppose that the innumerable articulated animals, which are counted by tens of thousands, nay, perhaps by hundreds of thousands, had never made their appearance upon the surface of our globe, with one single exception, that, for instance, our lobster (Homarus americanus) were the only representative of

[1] Compare Chap. III.

that extraordinarily diversified type, how should we introduce that species of animals in our systems? Simply as a genus with one species, by the side of all the other classes with their orders, families, etc., or as a family containing only one genus with one species, or as a class with one order and one genus, or as a class with one family and one genus? And should we acknowledge, by the side of Vertebrata, Mollusks, and Radiata, another type of Articulata, on account of the existence of that one lobster, or would it be natural to call him by a single name, simply as a species in contradistinction to all other animals? It was the consideration of this supposed case which led me to the investigations detailed below, which, I hope, may end in the ultimate solution of this apparently inextricable question.

Though what I have now to say about this supposed case cannot be fully appreciated before reading my remarks in the following chapter,[1] respecting the character of the different kinds of groups adopted in our systems, it must be obvious that our lobster, to be what we see these animals are, must have its frame constructed upon that very same plan of structure which it exhibits now, and if I should succeed in showing that there is a difference between the conception of a plan and the manner in which it is executed, upon which classes are founded in contradistinction to the types to which they belong, we might arrive at this distinction by a careful investigation of that single Articulate as well as by the study of all of them, and we might then recognize its type and ascertain its class characters as fully as if the type embraced several classes, and this class thousands of species. Then that animal has a form, which we could not fail to recognize, and if form can be shown to be characteristic of families, we could thus determine its family. Again, besides the general structure, showing the fundamental relations of all the systems of organs of the body to one another in their natural development, our investigation could be carried into the study of the details of that structure in every part, and thus lead to the recognition of what constitutes everywhere generic characters. Finally, as this animal has definite relations to the surrounding world, as the individuals living at the time bear definite relations to one another, as the parts of their body show definite proportions, and as the surface of the body exhibits a special ornamentation, the specific characters could be traced as fully as if a number of other species were at hand for comparison, and they might be drawn and described with sufficient accuracy to distinguish it at any future time from any other set of species found afterwards, however closely these might be allied to it. In this case, then, we should have to acknowledge a separate branch in the animal kingdom, with a class, a family, and a genus, to introduce this one species in its proper place in the system of animals. But this class would have no order, if orders determine the rank as ascertained by

[1] See Chap. II.

the complication of structure; for where there is but one representative of a type, there is no room for the question of its superiority or inferiority in comparison to others within the limits of the class, orders being groups subordinate to the type of the class. Yet, even in this case, the question of the standing of Articulata as a type among the other great branches of the animal kingdom would be open to our investigations; but it would assume another aspect from that it now presents, as the comparison of Articulata with the other types would then be limited to the lobster, and would lead to a very different result from that at which we may arrive now that this type includes such a large number of most extensively diversified representatives, belonging even to different classes. That such speculations are not idle must be apparent to any one who is aware that, during every period in the history of our globe, during the past geological ages,[1] the general relations, the numeric proportions, and the relative importance of all the types of the animal kingdom have been ever changing until their present relations were established. Here, then, the individuals of one species, as observed while living, simultaneously exhibit characters which, to be expressed satisfactorily and in conformity to what nature tells us, would require the establishment, not only of a distinct species, but also of a distinct genus, a distinct family, a distinct class, a distinct branch. Is this not in itself evidence enough that genera, families, orders, classes, and types have the same foundation in nature as species, and that the individuals living at the time have alone a material existence, they being the bearers not only of all these different categories of structure upon which the natural system of animals is founded, but also of all the relations which animals sustain to the surrounding world; thus showing that species do not exist in nature in a different way from the higher groups, as is so generally believed?

The divisions of animals according to branch, class, order, family, genus, and species, by which we express the results of our investigations into the relations of the animal kingdom, and which constitute the first question respecting the scientific systems of Natural History which we have to consider, seem to me to deserve the consideration of all thoughtful minds. Are those divisions artificial or natural? Are

[1] A series of classifications of animals and plants, exhibiting each a natural system of the types known to have existed simultaneously during the several successive geological periods, considered singly and without reference to the types of other ages, would show in a strong light the different relations in which the classes, the orders, the families, and even the genera and species, have stood to one another during each epoch. Such classifications would illustrate in the most impressive manner the importance of an accurate knowledge of the relative standing of all animals and plants, which can only be inferred from the perusal even of those palæontological works, in which fossil remains are illustrated according to their association in different geological formations, as in these works these remains are uniformly referred to a system established upon the study of all animals now known, thus lessening the impression of their peculiar combination for the period under consideration.

they the devices of the human mind to classify and arrange our knowledge in such a manner as to bring it more readily within our grasp, and facilitate further investigations, or have they been instituted by the Divine Intelligence as the categories of his mode of thinking?[1] Have we, perhaps, thus far been only the unconscious interpreters of a Divine conception, in our attempts to expound nature, and when, in our pride of philosophy, we thought that we were inventing systems of science, and classifying creation by the force of our own reason, have we followed only, and reproduced in our imperfect expressions, the plan whose foundations were laid in the dawn of creation, and the development of which we are laboriously studying, thinking, as we put together and arrange our fragmentary knowledge, that we are anew introducing order into chaos? Is this order the result of the exertions of human skill and ingenuity, or is it inherent in the objects themselves, so that the intelligent student of Natural History is led unconsciously by the study of the animal kingdom itself to these conclusions; the great divisions under which he arranges animals being indeed but the headings to the chapters of the great book which he is reading? To me it appears indisputable that this order and arrangement of our studies is based upon the natural, primitive relations of animal life; those systems, to which we have given the names of the great leaders of our science who first established them, being in truth but translations into human language of the thoughts of the Creator. And if this is indeed so, do we not find in this adaptability of the human intellect to the facts of creation, by which we become instinctively, and, as I have said, unconsciously, the translators of the thoughts of God, the most conclusive proof of our affinity with the Divine Mind, and is not this intellectual and spiritual connection with the Almighty worthy our deepest consideration? If there is any truth in the belief that man is made in the image of God, it is surely not amiss for the philosopher to endeavor by the study of his own mental operations to approximate the workings of the Divine Reason, learning from the nature of his own mind better to understand the Infinite Intellect from which it is derived. Such a suggestion may, at first sight, appear irreverent. But, which is the truly humble? He who, penetrating into the secrets of creation, arranges them under a formula, which he proudly calls his scientific system, or he who, in the same pursuit, recognizes his glorious affinity with the Creator, and, in deepest gratitude for so sublime a birthright, strives to be the faithful interpreter of that Divine Intellect with whom he is permitted, nay, with whom he is intended according to the laws of his being, to enter into communion.

[1] It must not be overlooked here that a system may be natural, that is, may agree in every respect with the facts in nature, and yet not be considered by its author as the manifestation of the thoughts of a Creator, but merely as the expression of a fact existing in nature, no matter how, which the human mind may trace and reproduce in a systematic form of its own invention.

I confess that this question as to the nature and foundation of our scientific classifications appears to me to have the deepest importance, an importance far greater indeed than is usually attached to it. If it can be proved that man has not invented, but only traced this systematic arrangement in nature, that these relations and proportions which exist throughout the animal and vegetable world have an intellectual, an ideal connection in the mind of the Creator, that this plan of creation, which so commends itself to our highest wisdom, has not grown out of the necessary action of physical laws, but was the free conception of the Almighty Intellect, matured in his thought, before it was manifested in tangible external forms, —if, in short, we can prove premeditation prior to the act of creation, we have done, once and for ever, with the desolate theory which refers us to the laws of matter as accounting for all the wonders of the universe, and leaves us with no God but the monotonous, unvarying action of physical forces, binding all things to their inevitable destiny.[1] I think our science has now reached that degree of advancement, in which we may venture upon such an investigation.

The argument for the existence of an intelligent Creator is generally drawn from

[1] I allude here only to the doctrines of materialists; but I feel it necessary to add, that there are physicists, who might be shocked at the idea of being considered as materialists, who are yet prone to believe that when they have recognized the laws which regulate the physical world, and acknowledged that these laws were established by the Deity, they have explained every thing, even when they have considered only the phenomena of the inorganic world, as if the world contained no living beings and as if these living beings exhibited nothing that differed from the inorganic world. Mistaking for a causal relation the intellectual connection observable between serial phenomena, they are unable to perceive any difference between disorder and the free, independent, and self-possessed action of a superior mind, and call mysticism, even a passing allusion to the existence of an immaterial principle in animals, which they acknowledge themselves in man. [POWELL's Essays, etc., p. 478, 385, and 466.] I would further remark, that, when speaking of creation in contradistinction with reproduction, I mean only to allude to the difference there is between the regular course of phenomena in nature and the establishment of that order of things, without attempting to explain either; for in whatever manner any state of things which has prevailed for a time upon earth may have been introduced, it is self-evident that its establishment and its maintenance for a determined period are two very different things, however frequently they may be mistaken as identical. It is further of itself plain that the laws which may explain the phenomena of the material world, in contradistinction from the organic, cannot be considered as accounting for the existence of living beings, even though these have a material body, unless it be actually shown that the action of these laws implies by their very nature the production of such beings. Thus far, Cross's experiments are the only ones offered as proving such a result. I do not know what physicists may think about them now; but I know that there is scarcely a zoölogist who doubts that they only exhibited a mistake. Life in appropriating the physical world to itself with all its peculiar phenomena exhibits, however, some of its own and of a higher order, which cannot be explained by physical agencies. The circumstance that life is so deeply rooted in the inorganic nature, affords, nevertheless, a strong temptation to explain one by the other; but we shall see presently how fallacious these attempts have been.

the adaptation of means to ends, upon which the Bridgewater treatises, for example, have been based.[1] But this does not appear to me to cover the whole ground, for we can conceive that the natural action of objects upon each other should result in a final fitness of the universe, and thus produce an harmonious whole; nor does the argument derived from the connection of organs and functions seem to me more satisfactory, for, beyond certain limits, it is not even true. We find organs without functions, as, for instance, the teeth of the whale, which never cut through the gum, the breast in all males of the class of mammalia; these and similar organs are preserved in obedience to a certain uniformity of fundamental structure, true to the original formula of that division of animal life, even when not essential to its mode of existence. The organ remains, not for the performance of a function, but with reference to a plan,[2] and might almost remind us of what we often see in human structures, when, for instance, in architecture, the same external combinations are retained for the sake of symmetry and harmony of proportion, even when they have no practical object.

I disclaim every intention of introducing in this work any evidence irrelevant to my subject, or of supporting any conclusions not immediately flowing from it; but I cannot overlook nor disregard here the close connection there is between the facts ascertained by scientific investigations, and the discussions now carried on respecting the origin of organized beings. And though I know those who hold it to be very unscientific to believe that thinking is not something inherent in matter, and that there is an essential difference between inorganic and living and thinking beings, I shall not be prevented by any such pretensions of a false philosophy from expressing

[1] The Bridgewater Treatises, on the Power, Wisdom, and Goodness of God, as Manifested in the Creation: CHALMERS, (THOMAS,) The Adaptation of External Nature to the Moral and Intellectual Constitution of Man, Glasgow, 1839, 2 vols. 8vo. — KIDD, (JOHN,) On the Adaptation of External Nature to the Physical Condition of Man, London, 1833, 1 vol. 8vo. — WHEWELL, (WILL.,) Astronomy and General Physics considered with Reference to Natural Theology, London, 1839, 1 vol. 8vo. — BELL, (CHARLES,) The Hand, its Mechanism and Vital Endowments, as evincing Design, London, 1833, 1 vol. 8vo. — ROGET, (PETER MARK,) Animal and Vegetable Physiology, considered with Reference to Natural Theology, London, 1834, 2 vols. 8vo. — BUCKLAND, (WILL.,) Geology and Mineralogy considered with Reference to Natural Theology, London, 1836, 2 vols. 8vo.; 2d edit. 1837. — KIRBY, (WILL.,) The Power, Wisdom, and Goodness of God, as Manifested in the Creation of Animals, and in their History, Habits, and Instincts, London, 1835, 2 vols. 8vo. — PROUT, (WILL.,) Chemistry, Meteorology, and the Function of Digestion, considered with Reference to Natural Theology, London, 1834, 1 vol. 8vo. Compare also: STRAUSS-DURKHEIM, (HERC.,) Théologie de la Nature, Paris, 1852, 3 vols. 8vo. — MILLER, (HUGH,) Footprints of the Creator, Edinburgh, 1849, 1 vol. 12mo. — BABBAGE, (C.,) The Ninth Bridgewater Treatise, a Fragment, London, 1838, 1 vol. 8vo.; 2d edit.

[2] The unity of structure of the limbs of club-footed or pinnated animals, in which the fingers are never moved, with those which enjoy the most perfect articulations and freedom of motion, exhibits this reference most fully.

my conviction that as long as it cannot be shown that matter or physical forces do actually reason, I shall consider any manifestation of thought as evidence of the existence of a thinking being as the author of such thought, and shall look upon an intelligent and intelligible connection between the facts of nature as direct proof of the existence of a thinking God,[1] as certainly as man exhibits the power of thinking when he recognizes their natural relations.

As I am not writing a didactic work, I will not enter here into a detailed illustration of the facts relating to the various subjects submitted to the consideration of my reader, beyond what is absolutely necessary to follow the argument, nor dwell at any length upon the conclusions to which they lead, but simply recall the leading features of the evidence, assuming in the argument a full acquaintance with the whole range of data upon which it is founded, whether derived from the affinities or the anatomical structure of animals, or from their habits and their geographical distribution, from their embryology, or from their succession in past geological ages, and the peculiarities they have exhibited during each,[2] believing, as I do, that isolated and disconnected facts are of little consequence in the contemplation of the whole plan

[1] I am well aware that even the most eminent investigators consider the task of science at an end, as soon as the most general relations of natural phenomena have been ascertained. To many the inquiry into the primitive cause of their existence seems either beyond the reach of man, or as belonging rather to philosophy than to physics. To these the name of God appears out of place in a scientific work, as if the knowledge of secondary agencies constituted alone a worthy subject for their investigations, and as if nature could teach nothing about its Author. Many, again, are no doubt prevented from expressing their conviction that the world was called into existence and is regulated by an intelligent God, either by the fear of being supposed to share clerical or sectarian prejudices; or because it may be dangerous for them to discuss freely such questions without acknowledging at the same time the obligation of taking the Old Testament as the standard by which the validity of their results is to be measured. Science, however, can only prosper when confining itself within its legitimate sphere; and nothing can be more detrimental to its true dignity than discussions like those which took place at the last meeting of the German association of naturalists, in Göttingen, and which have since then been carried on in several pamphlets in which bigotry vies with personality and invective.

[2] Many points little investigated thus far by most naturalists, but to which I have of late years paid particular attention, are here presented only in an aphoristic form, as results established by extensive investigations, though unpublished, most of which will be fully illustrated in my following volumes, or in a special work upon the plan of the creation. (See AGASSIZ, (L.,) On the Difference between Progressive, Embryonic, and Prophetic Types in the Succession of Organized Beings, Proceed. 2d Meeting Amer. Assoc. for the Advancement of Science, held at Cambridge in 1849, Boston, 1850, 1 vol. 8vo., p. 432.) Meanwhile I refer in foot notes to such works as contain the materials already on hand for the discussion of these subjects, even when presented in a different light. I would only beg leave to add, that in these references I have by no means attempted to quote all the writers upon the various topics under consideration, but only the most prominent and most instructive, and here and there some condensed accounts of the facts in more elementary works, by the side of the original papers.

of creation, and that without a consideration of all the facts furnished by the study of the habits of animals, by their anatomy, their embryology, and the history of the past ages of our globe, we shall never arrive at the knowledge of the natural system of animals.

Let us now consider some of these topics more specially.

SECTION II.

SIMULTANEOUS EXISTENCE OF THE MOST DIVERSIFIED TYPES UNDER IDENTICAL CIRCUMSTANCES.

It is a fact which seems to be entirely overlooked by those who assume an extensive influence of physical causes upon the very existence of organized beings, that the most diversified types of animals and plants are everywhere found under identical circumstances. The smallest sheet of fresh water, every point upon the seashore, every acre of dry land, teems with a variety of animals and plants. The narrower the boundaries are, which may be assigned as the primitive home of all these beings, the more uniform must be the conditions under which they are assumed to have originated; so uniform, indeed, that in the end the inference would be, that the same physical causes could produce the most diversified effects.[1] To concede,

[1] In order fully to appreciate the difficulty alluded to here, it is only necessary to remember how complicated, and at the same time how localized the conditions are under which animals multiply. The egg originates in a special organ, the ovary; it grows there to a certain size, until it requires fecundation, that is, the influence of another living being, or at least of the product of another organ, the spermary, to determine the further development of the germ, which, under the most diversified conditions, in different species, passes successively through all those changes which lead to the formation of a new perfect being. I then would ask, is it probable that the circumstances under which animals and plants originated for the first time can be much simpler, or even as simple, as the conditions necessary for their reproduction only, after they have once been created? Preliminary, then, to their first appearance, the conditions necessary for their growth must have been provided for, if, as I believe, they were created as eggs, which conditions must have been conformable to those in which the living representatives of the types first produced, now reproduce themselves. If it were assumed that they originated in a more advanced stage of life, the difficulties would be still greater, as a moment's consideration cannot fail to show, especially if it is remembered how complicated the structure of some of the animals was, which are known to have been among the first inhabitants of our globe. When investigating this subject, it is of course necessary to consider the first appearance of animals and plants, upon the basis of probabilities only, or even simply upon that of possibilities; as with reference to these first-born, at least, the transmutation theory furnishes no explanation of their existence.

For every species belonging to the first fauna and the first flora which have existed upon earth, special

on the contrary, that these organisms may have appeared in the beginning over a wide area, is to grant, at the same time, that the physical influences under which they existed at first were not so specific as to justify the assumption that these could be the cause of their appearance. In whatever connection, then, the first appearance of organized beings upon earth is viewed, whether it is assumed that they originated within the most limited areas, or over the widest range of their present natural geographical distribution, animals and plants being everywhere diversified to the most extraordinary extent, it is plain that the physical influences under which they subsist cannot logically be considered as the cause of that diversity. In this, as in every other respect, when considering the relations of animals and plants to the conditions under which they live, or to one another, we are inevitably led to look beyond the material facts of the case for an explanation of their existence. Those who have taken another view of this subject, have mistaken the action and reaction which exist everywhere between organized beings, and the physical influences under which they live[1] for a causal or genetic connection, and carried their mistake so far as to assert that these manifold influences could really extend to the production of these beings, not considering how inadequate such a cause would be, and that even the action of physical agents upon organized beings presupposes the very existence of those beings.[2] The simple fact that there has been a period in the history

relations, special contrivances must therefore have been provided. Now, what would be appropriate for the one, would not suit the other, so that excluding one another in this way, they cannot have originated upon the same point; while within a wider area, physical agents are too uniform in their mode of action to have laid the foundation for so many such specific differences as existed between the first inhabitants of our globe.

[1] See, below, Sect. 16.

[2] A critical examination of this point may dispel much of the confusion which prevails in the discussions relating to the influence of physical causes upon organized beings. That there exist definite relations between animals as well as plants and the mediums in which they live, no one at all familiar with the phenomena of the organic world can doubt; that these mediums and all physical agents at work in nature, have a certain influence upon organized beings is equally plain. But before any such action can take place and be felt, organized beings must exist. The problem before us involves, therefore, two questions, the influence of physical agents upon animals and plants already in existence, and the origin of these beings. Granting the influence of these agents upon organized beings to the fullest extent to which it may be traced, (see Sect. 16,) there remains still the question of their origin upon which neither argument nor observation has yet thrown any light. But according to some, they originated spontaneously by the immediate agency of physical forces, and have become successively more and more diversified by changes produced gradually upon them, by these same forces. Others believe that there exist laws in nature which were established by the Deity in the beginning, to the action of which the origin of organized beings may be ascribed; while according to others, they owe their existence to the immediate intervention of an intelligent Creator. It is the object of the following paragraphs to show that there are neither agents nor laws in nature known to physicists under the influence and by the action of which these beings could have originated; that, on the contrary, the very nature of these be-

of our earth, now well known to geologists,[1] when none of these organized beings as yet existed, and when, nevertheless, the material constitution of our globe, and the physical forces acting upon it, were essentially the same as they are now,[2] shows that these influences are insufficient to call into existence any living being.

Physicists know, indeed, these physical agents more accurately than the naturalists, who ascribe to them the origin of organized beings; let us then ask them, whether the nature of these agents is not specific, whether their mode of action is not specific? They will all answer, that they are. Let us further inquire of them, what evidence there is, in the present state of our knowledge, that at any time these physical agents have produced any thing they no longer do produce, and what probability there is that they may ever have produced any organized being? If I am not greatly mistaken, the masters in that department of science will, one and all, answer, none whatever.

But the character of the connections between organized beings and the physical conditions under which they live is such as to display thought;[3] these connections are therefore to be considered as established, determined, and regulated by a thinking being. They must have been fixed for each species at its beginning, while the fact of their permanency through successive generations[4] is further evidence that with their natural relations to the surrounding world were also determined the relations of individuals to one another,[5] their generic as well as their family relations, and every higher grade of affinity,[6] showing, therefore, not only thought, in reference to the physical conditions of existence, but such comprehensive thoughts as would embrace simultaneously every characteristic of each species.

Every fact relating to the geographical distribution of animals and plants might be alluded to in confirmation of this argument, but especially the character of every

ings, and their relations to one another and to the world in which they live, exhibit thought, and can therefore be referred only to the immediate action of a thinking being, even though the manner in which they were called into existence remains for the present a mystery.

[1] Few geologists only may now be inclined to believe that the lowest strata known to contain fossils, are not the lowest deposits formed since the existence of organized beings upon earth. But even those who would assume that still lower fossiliferous beds may yet be discovered, or may have entirely disappeared by the influence of plutonic agencies, (POWELL's Essays, etc., p. 424,) must acknowledge the fact that everywhere in the lowest rocks known to contain fossils at all, there is a variety of them found together. (See Sect. 7.) Moreover, the similarity in the character of the oldest fossils found in different parts of the world, goes far, in my opinion, to prove that we actually do know the earliest types of the animal kingdom which have inhabited our globe. This conclusion seems fully sustained by the fact that we find everywhere below this oldest set of fossiliferous beds, other stratified rocks in which no trace of organized beings can be found.

[2] See, below, Sect. 21.

[3] See, below, Sect. 16.

[4] See, below, Sect. 15.

[5] See, below, Sect. 17.

[6] See, below, Sect. 6.

fauna and every flora upon the surface of the globe. How great the diversity of animals and plants living together in the same region may be, can be ascertained by the perusal of special works upon the Zoölogy and Botany of different countries, or from special treatises upon the geographical distribution of animals and plants.[1] I need, therefore, not enter into further details upon this subject, especially since it is discussed more fully below.[2]

It might, perhaps, be urged, that animals living together in exceptional conditions, and exhibiting structural peculiarities apparently resulting from these conditions, such as the blind fish,[3] the blind crawfish, and the blind insects of the Mammoth Cave in Kentucky, furnish uncontrovertible evidence of the immediate influence of those exceptional conditions upon the organs of vision. If this, however, were the case, how does it happen that that remarkable fish, the *Amblyopsis spelæus*, has only such remote affinities to other fishes? Or were, perhaps, the sum of influences at work to make that fish blind, capable also of devising such a combination of structural characters as that fish has in common with all other fishes, with those peculiarities which at the same time distinguish it? Does not, rather, the existence of a rudimentary eye discovered by Dr. J. Wyman in the blind fish show, that these animals, like all others, were created with all their peculiarities by the fiat of the Almighty, and this rudiment of eyes left them as a remembrance of the general plan of structure of the great type to which they belong? Or will, perhaps, some one of those naturalists who know so much better than the physicists what physical forces may produce, and that they may produce, and have produced every living being known, explain also to us why subterraneous caves in America produce blind fishes, blind crustacea, and blind insects, while in Europe they produce nearly blind reptiles? If there is no thought in the case, why is it, then, that this very reptile, the *Proteus anguinus*, forms, with a number of other reptiles living in North America and in Japan, one of

[1] SCHMARDA, Die geographische Verbreitung der Thiere, 3 vols. 8vo. Wien, 1853. — SWAINSON, (W.,) A Treatise on the Geography and Classification of Animals, London, 1835, 1 vol. 12mo. — ZIMMERMANN, (E. A. G.,) Specimen Zoologiæ geographicæ, Quadrupedum domicilia et migrationes sistens, Lugduni-Batav., 1777, 1 vol. 4to. — HUMBOLDT, Essai sur la géographie des plantes, 4to., Paris, 1805; and Ansichten der Natur, 3d edit., 12mo., Stuttgardt and Tübingen, 1849. — ROBERT BROWN, General Remarks on the Botany of Terra Australis, London, 1814. — SCHOUW, Grundzüge einer allgemeinen Pflanzengeographie, 1 vol. 8vo., with atlas in fol., Berlin, 1823. — ALPH. DE CANDOLLE, Géographie botanique raisonnée, 2 vols. 8vo., Paris, 1855. References to special works may be found below, Sect. 9.

[2] See, below, Sect. 9.

[3] WYMAN, (JEF.,) Description of a Blind Fish, from a Cave in Kentucky, SILLIMAN's Jour., 1843, vol. 45, p. 94, and 1854, vol. 17, p. 258. — TELLKAMPF, (TH. G.,) Ueber den blinden Fisch der Mammuthhöhle in Kentucky, in MÜLLER's Archiv, 1844, p. 381. — TELLKAMPF, (TH. G.,) Beschreibung einiger neuer in der Mammuthhöhle aufgefundener Gattungen von Gliederthieren, WIEGMAN's Archiv, 1844, vol. I., p. 318. — AGASSIZ, (L.,) Observations on the Blind Fish of the Mammoth Cave, SILLIMAN's Journal, 1851, vol. 11, p. 127.

the most natural series known in the animal kingdom, every member of which exhibits a distinct grade [1] in the scale?

After we have freed ourselves from the mistaken impression that there may be some genetic connection between physical forces and organized beings, there remains a vast field of investigation to ascertain the true relations between both, to their full extent, and within their natural limits.[2] A mere reference to the mode of breathing of different types of animals, and to their organs of locomotion, which are more particularly concerned in these relations, will remind every naturalist of how great importance in classification is the structure of these parts, and how much better they might be understood in this point of view, were the different structures of these organs more extensively studied in their direct reference to the world in which animals live. If this had been done, we should no longer call by the same common name of legs and wings organs so different as the locomotive appendages of the insects and those of the birds? We should no longer call lungs the breathing cavity of snails, as well as the air pipes of mammalia, birds, and reptiles? A great reform is indeed needed in this part of our science, and no study can prepare us better for it than the investigation of the mutual dependence of the structure of animals, and the conditions in which they live.

SECTION III.

REPETITION OF IDENTICAL TYPES UNDER THE MOST DIVERSIFIED CIRCUMSTANCES.

As much as the diversity of animals and plants living under identical physical conditions, shows the independence of organized beings from the medium in which they dwell, so far as their origin is concerned, so independent do they appear again from the same influences when we consider the fact that identical types occur everywhere upon earth under the most diversified circumstances. If we sum up all these various influences and conditions of existence under the common appellation of cosmic influences, or of physical causes, or of climate in the widest sense of the word, and then look around us for the extreme differences in that respect upon the whole surface of the globe, we find still the most similar, nay identical types (and I allude here, under the expression of type, to the most diversified acceptations of the word) living normally under their action. There is no structural difference between the herrings of the Arctic, or those of the Temperate zone, or those of the Tropics,

[1] See, below, Sect. 12.

[2] See, below, Sect. 16.

or those of the Antarctic regions; there are not any more between the foxes and wolves of the most distant parts of the globe.[1] Moreover, if there were any, and the specific differences existing between them were insisted upon, could any relation between these differences and the cosmic influences under which they live be pointed out, which would at the same time account for the independence of their structure in general? Or, in other words, how could it be assumed that while these causes would produce specific differences, they would at the same time produce generic identity, family identity, ordinal identity, class identity, typical identity? Identity in every thing that is truly important, high, and complicated in the structure of animals, produced by the most diversified influences, while at the same time these extreme physical differences, considered as the cause of the existence of these animals, would produce diversity in secondary relations only! What logic!

Does not all this show, on the contrary, that organized beings exhibit the most astonishing independence of the physical causes under which they live; an independence so great that it can only be understood as the result of a power governing these physical causes as well as the existence of animals and plants, and bringing all into harmonious relations by adaptations which never can be considered as cause and effect?

When naturalists have investigated the influence of physical causes upon living beings, they have constantly overlooked the fact that the features which are thus modified are only of secondary importance in the life of animals and plants, and that neither the plan of their structure, nor the various complications of that structure, are ever affected by such influences. What, indeed, are the parts of the body which are, in any way, affected by external influences? Chiefly those which are in immediate contact with the external world, such as the skin, and in the skin chiefly its outer layers, its color, the thickness of the fur, the color of the hair, the feathers, and the scales; then the size of the body and its weight, as far as it is dependent on the quality and quantity of the food; the thickness of the shell of Mollusks, when they live in waters or upon a soil containing more or less limestone, etc. The rapidity or slowness of the growth is also influenced in a measure by the course of the seasons, in different years; so is also the fecundity, the duration of life, etc. But all this has nothing to do with the essential characteristics of animals.

A book has yet to be written upon the independence of organized beings of physical causes, as most of what is generally ascribed to the influence of physical agents upon organized beings ought to be considered as a connection established between them in the general plan of creation.

[1] Innumerable other examples might be quoted, which will readily present themselves to professional naturalists; those mentioned above may suffice for my argument.

SECTION IV.

UNITY OF PLAN IN OTHERWISE HIGHLY DIVERSIFIED TYPES.

Nothing is more striking throughout the animal and vegetable kingdoms than the unity of plan in the structure of the most diversified types. From pole to pole, in every longitude, mammalia, birds, reptiles, and fishes, exhibit one and the same plan of structure,[1] involving abstract conceptions of the highest order, far transcending the broadest generalizations of man, for it is only after the most laborious investigations man has arrived at an imperfect understanding of this plan. Other plans, equally wonderful, may be traced in Articulata, in Mollusks, in Radiata,[2] and in the various types of plants,[3] and yet this logical connection, these beautiful harmonies, this infinite diversity in unity are represented by some as the result of forces exhibiting no trace of intelligence, no power of thinking, no faculty of combination, no knowledge of time and space. If there is any thing which places man above all other beings in nature, it is precisely the circumstance that he possesses those noble attributes without which, in their most exalted excellence and perfection, not one of these

[1] With reference to this point, consult: OKEN, (LOR.,) Ueber die Bedeutung der Schädel-Knochen, Frankfort, 1807, 4to. (pamphlet.) — SPIX, (J. B.) Cephalogenesis, sive capitis ossei structura, formatio et significatio, Monachii, 1815, fol. — GEOFFROY ST. HILAIRE, (ET.,) Philosophie anatomique, Paris, 1818–1823, 2 vols. 8vo., and several papers in the Annal. des sc. nat., Annal. and Mém. du Muséum, etc. — CARUS, (C. G.,) Von den Ur-Theilen des Knochen- und Schalengerüstes, Leipzig, 1828, fol. — OWEN, (R.) On the Archetype and Homologies of the Vertebrate Skeleton, London, 1848, 8vo.

[2] OKEN, (LOR.,) Lehrbuch der Naturphilosophie, Jena, 1809–11, 3 vols. 8vo.; Engl. Elements of Physio-philosophy, Ray Society, London, 1847, 8vo. — CUVIER, (G.,) Sur un nouveau rapprochement à établir entre les classes qui composent le Règne Animal, Annales du Muséum, vol. xix., 1812. — SAVIGNY, (J. C.,) Mémoires sur les animaux sans vertèbres, Paris, 1816, 8vo. — BAER, (C. E. v.,) Ueber Entwickelungsgeschichte der Thiere, Königsberg, 1828, 4to. — LEUKARDT, (R.,) Ueber die Morphologie und die Verwandtschaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 8vo. — AGASSIZ, (L.,) Twelve Lectures on Comparative Embryology, Boston, 1849, 8vo. — On Animal Morphology, Proc. Amer. Assoc. for the Adv. of Science, Boston, 1850, 8vo., p. 411. I would call particular attention to this paper, which has immediate reference to the subject of this chapter. — CARUS, (V.,) System der thierischen Morphologie, Leipzig, 1853, 1 vol. 8vo.

[3] GÖTHE, (J. W.,) Zur Naturwissenhaft überhaupt, besonders zur Morphologie, Stuttgardt, 1817–24, 2 vols. 8vo.; French, Oeuvres d'histoire naturelle, comprenant divers mémoires d'Anatomie comparée, de Botanique et de Géologie, traduits et annotés par Ch. Fr. Martins, Paris, 1837, 8vo.; atlas in fol. — DECANDOLLE, (A. P.,) Organographie végétale, Paris, 1827, 2 vols. 8vo. — BRAUN, (AL.,) Vergleichende Untersuchung über die Ordnung der Schuppen an den Tannenzapfen, als Einleitung zur Untersuchung der Blattstellung überhaupt, Act. Nov. Ac. Nat. Curios., vol. xv., 1829. — Das Individuum der Pflanze, Akad. d. Wiss., Berlin, 1853, 4to.

general traits of relationship so characteristic of the great types of the animal and vegetable kingdoms, can be understood, or even perceived. How, then, could these relations have been devised without similar powers? If all these relations are almost beyond the reach of the mental powers of man, and if man himself is part and parcel of the whole system, how could this system have been called into existence if there does not exist One Supreme Intelligence, as the Author of all things?

SECTION V.

CORRESPONDENCE IN THE DETAILS OF STRUCTURE IN ANIMALS OTHERWISE ENTIRELY DISCONNECTED.

During the first decade of this century, naturalists began to study relations among animals which had escaped almost entirely the attention of earlier observers. Though Aristotle knew already that the scales of fishes correspond to the feathers of birds,[1] it is but recently that anatomists have discovered the close correspondence which exists between all the parts of all animals belonging to the same type, however different they may appear at first sight. Not only is the wing of the bird identical in its structure with the arm of man, or the fore leg of a quadruped, it agrees quite as closely with the fin of the whale, or the pectoral fin of the fish, and all these together correspond in the same manner with their hind extremities. Quite as striking a coincidence is observed between the solid skull-box, the immovable bones of the face and the lower jaw of man and the other mammalia, and the structure of the bony frame of the head of birds, turtles, lizards, snakes, frogs, and fishes. But this correspondence is not limited to the skeleton; every other system of organs exhibits in these animals the same relations, the same identity in plan and structure, whatever be the differences in the form of the parts, in their number, and even in their functions. Such an agreement in the structure of animals is called their homology, and is more or less close in proportion as the animals in which it is traced are more or less nearly related.

The same agreement exists between the different systems and their parts in Articulata, in Mollusks, and in Radiata, only that their structure is built up upon respectively different plans, though in these three types the homologies have not yet been traced to the same extent as among Vertebrata. There is therefore still a wide

[1] ARISTOTELES, Historia Animalium, Lib. I., Chap. 1, Sect. 4. *ὃ γὰρ ἐν ὄρνιθι πτερὸν, τοῦτο ἐν ἰχθύϊ ἐστὶ λεπίς.* — Consult also the authors referred to in Sect. 4, notes 1 and 2, and the many other works, pamphlets, and papers, quoted by them, which are too numerous to be mentioned here.

field open for investigations in this most attractive branch of Zoölogy. So much, however, is already plain from what has been done in this department of our science, that the identity of structure among animals does not extend to all the four branches of the animal kingdom; that, on the contrary, every great type is constructed upon a distinct plan, so peculiar, indeed, that homologies cannot be extended from one type to the other, but are strictly limited within each of them. The more remote resemblance which may be traced between representatives of different types, is founded upon analogy,[1] and not upon affinity. While, for instance, the head of fishes exhibits the most striking homology with that of reptiles, birds, and mammalia, as a whole, as well as in all its parts, that of Articulata is only analogous to it and to its part. What is commonly called head in Insects is not a head like that of Vertebrata; it has not a distinct cavity for the brain, separated from that which communicates below the neck with the chest and abdomen; its solid envelope does not consist of parts of an internal skeleton, surrounded by flesh, but is formed of external rings, like those of the body, soldered together; it contains but one cavity, which includes the cephalic ganglion, as well as the organs of the mouth, and all the muscles of the head. The same may be said of the chest, the legs and wings, the abdomen, and all the parts they contain. The cephalic ganglion is not homologous to the brain, nor are the organs of senses homologous to those of Vertebrata, even though they perform the same functions. The alimentary canal is formed in a very different way in the embryos of the two types, as are also their respiratory organs, and it is as unnatural to identify them, as it would be still to consider gills and lungs as homologous among Vertebrata now embryology has taught us that in different stages of growth these two kinds of respiratory organs exist in all Vertebrata in very different organic connections one from the other.

What is true of the branch of Articulata when compared to that of Vertebrata, is equally true of the Mollusks and Radiata when compared with one another or with the two other types, as might easily be shown by a fuller illustration of the correspondence of their structure, within these limits. This inequality in the fundamental character of the structure of the four branches of the animal kingdom points to the necessity of a radical reform in the nomenclature of comparative anatomy.[2] Some naturalists, however, have already extended such comparisons respecting the structure of animals beyond the limits pointed out by nature, when they have attempted to show that all structures may be reduced to one norm, and

[1] See SWAINSON, (W.,) On the Geography and Classification of Animals, London, 1835, 12mo., p. 129, where this point is ably discussed.

[2] See AGASSIZ, (L.,) On the Structure and Homologies of Radiated Animals, with Reference to the Systematic Position of the Hydroid Polypi, Proc. of the Amer. Assoc. for the Adv. of Science for 1849, Boston, 1850, 1 vol. 8vo. p. 389.

when they have maintained, for instance, that every bone existing in any Vertebrate must have its counterpart in every other species of that type. To assume such a uniformity among animals, would amount to denying to the Creator even as much freedom in expressing his thoughts as man enjoys.

If it be true, as pointed out above, that all animals are constructed upon four different plans of structure, in such a manner that all the different kinds of animals are only different expressions of these fundamental formulæ, we may well compare the whole animal kingdom to a work illustrating four great ideas, between which there is no other connecting link than the unity exhibited in the eggs in which their most diversified manifestations are first embodied in an embryonic form, to undergo a series of transformations, and appear in the end in that wonderful variety of independent living beings which inhabit our globe, or have inhabited it from the earliest period of the existence of life upon its surface.

The most surprising feature of the animal kingdom seems, however, to me to rest neither in its diversity, nor in the various degrees of complication of its structure, nor in the close affinity of some of its representatives, while others are so different, nor in the manifold relations of all of them to one another and the surrounding world, but in the circumstance that beings endowed with such different and such unequal gifts should nevertheless constitute an harmonious whole, intelligibly connected in all its parts.

SECTION VI.

VARIOUS DEGREES AND DIFFERENT KINDS OF RELATIONSHIP AMONG ANIMALS.

The degrees of relationship existing between different animals are most diversified. They are not only akin as representatives of the same species, bearing as such the closest resemblance to one another; different species may also be related as members of the same genus, the representatives of different genera may belong to the same family, and the same order may contain different families, the same class different orders, and the same type several classes. The existence of different degrees of affinity between animals and plants which have not the remotest genealogical connection, which live in the most distant parts of the world, which have existed in periods long gone by in the history of our earth, is a fact beyond dispute, at least, within certain limits, no longer controverted by well informed observers. Upon what can this be founded? Is it that the retentive capacity of the memory of the physical forces at work upon this globe is such, that after bringing forth a type according to one pattern, in the infancy of this earth, that pattern was adhered to under conditions,

no matter how diversified, to reproduce, at another period, something similar, and so on, through all ages, until at the period of the establishment of the present state of things, all the infinitude of new animals and new plants which now crowd its surface, should be cast in these four moulds, in such a manner as to exhibit, notwithstanding their complicated relations to the surrounding world, all those more deeply seated general relations, which establish among them the different degrees of affinity we may trace so readily in all the representatives of the same type? Does all this really look more like the working of blind forces than like the creation of a reflective mind establishing deliberately all the categories of existence we recognize in nature, and combining them in that wonderful harmony which unites all things into such a perfect system, that even to read it, as it is established, or even with all the imperfections of a translation, should be considered as the highest achievement of the maturest genius?

Nothing seems to me to prove more directly and more fully the action of a reflective mind, to indicate more plainly a deliberate consideration of the subject, than the different categories upon which species, genera, families, orders, classes, and branches are founded in nature, and manifested in material reality in a succession of individuals, the life of which is limited in its duration to comparatively very short periods. The great wonder in these relations consists in the fugitive character of the bearers of this complicated harmony. For while species persist during long periods, the individuals which represent them are ever changing, one set dying after the other, in quick succession. Genera, it is true, may extend over longer periods; families, orders, and classes may even have existed during all periods during which animals have existed at all; but whatever may have been the duration of their existence, at all times these different divisions have stood in the same relation to one another and to their respective branches, and have always been represented upon our globe in the same manner, by a succession of ever renewed and short-lived individuals.

As, however, the second chapter of this work is entirely devoted to the consideration of the different kinds and the different degrees of affinity existing among animals, I will not enter here into any details upon this subject, but simply recall the fact that, in the course of time, investigators have agreed more and more with one another in their estimates of these relations, and built up systems more and more conformable to one another. This result, which is fully exemplified by the history of our science,[1] is in itself sufficient to show that there is a system in nature

[1] SPIX, (J.,) Geschichte und Beurtheilung aller Systeme in der Zoologie, Nürnberg, 1811, 1 vol. 8vo. — CUVIER, (G.,) Histoire des progrès des sciences naturelles, Paris, 1826, 4 vols. 8vo. — Histoire des sciences naturelles, etc., Paris, 1841, 5 vols. 8vo. — DEBLAINVILLE, (H.,) Histoire des sciences de

to which the different systems of authors are successive approximations, more and more closely agreeing with it, in proportion as the human mind has understood nature better. This growing coincidence between our systems and that of nature shows further the identity of the operations of the human and the Divine intellect; especially when it is remembered to what an extraordinary degree many *à priori* conceptions, relating to nature, have in the end proved to agree with the reality, in spite of every objection at first offered by empiric observers.

SECTION VII.

SIMULTANEOUS EXISTENCE IN THE EARLIEST GEOLOGICAL PERIODS, OF ALL THE GREAT TYPES OF ANIMALS.

It was formerly believed by geologists and palæontologists that the lowest animals first made their appearance upon this globe, and that they were followed by higher and higher types, until man crowned the series. Every geological museum, representing at all the present state of our knowledge, may now furnish the evidence that this is not the case. On the contrary, representatives of numerous families belonging to all the four great branches of the animal kingdom, are well known to have existed simultaneously in the oldest geological formations.[1] Nevertheless, I well remember when I used to hear the great geologists of the time assert, that the Corals were the first inhabitants of our globe, that Mollusks and Articulata followed in order, and that Vertebrates did not appear until long after these. What an extraordinary change the last thirty years have brought about in our knowledge, and the doctrines generally adopted respecting the existence of animals and plants in past ages! However much naturalists may still differ in their views regarding the origin, the gradation, and the affinities of animals, they now all know that neither Radiata, nor Mollusks, nor Articulata, have any priority one over the other, as to the time

l'organisation et de leurs progrès, Paris, 1847, 3 vols. 8vo. — POUCHET, (F. A.,) Histoire des sciences naturelles au moyen âge, Paris, 1853, 1 vol. 8vo. Compare, also, Chap. II., below.

[1] MURCHISON, (R. I.,) The Silurian System, London, 1839, 1 vol. 4to. — MURCHISON, (SIR R. I.,) Siluria. The History of the Oldest Known Rocks containing Fossils, London, 1854, 1 vol. 8vo. — MURCHISON, (R. I.,) DE VERNEUIL, (ED.,) and KAISERLING, (COUNT ALEX. VON,) The Geology of Russia in Europe, and the Ural Mountains, London, 1845, 2 vols. 4to. — HALL, (JAMES,) Palæontology of New York, Albany, 1847–52, 2 vols. 4to. — BARRANDE, (J.,) Système silurien du centre de la Bohème, Prague and Paris, 1852, 2 vols. 4to. — SEDGWICK, (A.,) and MCKOY, (FR.,) British Palæozoic Rocks and Fossils, London, 1851, 4to. 2 fasc.; not yet complete.

of their first appearance upon earth; and though some still maintain that Vertebrata originated somewhat later, it is universally conceded that they were already in existence toward the end of the first great epoch in the history of our globe. I think it would not be difficult to show upon physiological grounds that their presence upon earth dates from as early a period as any of the three other great types of the animal kingdom, since fishes exist wherever Radiata, Mollusks, and Articulata are found together, and the plan of structure of these four great types constitutes a system intimately connected in its very essence. Moreover, for the last twenty years, every extensive investigation among the oldest fossiliferous rocks has carried the origin of Vertebrata step by step further back, so that whatever may be the final solution of this vexed question, so much is already established by innumerable facts, that the idea of a gradual succession of Radiata, Mollusks, Articulata, and Vertebrata, is for ever out of the question. It is proved beyond doubt, that Radiata, Mollusca, and Articulata are everywhere found together in the oldest geological formations, and that very early Vertebrata are associated with them, to continue together through all geological ages to the present time. This shows that even in those early days of the existence of our globe, when its surface did not yet present those diversified features which it has exhibited in later periods, and which it exhibits in still greater variety now, animals belonging to all the great types now represented upon earth, were simultaneously called into existence. It shows, further, that unless the physical elements then at work could have devised such plans, and impressed them upon the material world as the pattern upon which Nature was to build for ever afterwards, no such general relations as exist among all animals, of all geological periods, as well as among those now living, could ever have existed.

This is not all: every class among Radiata, Mollusks, and Articulata, is known to have been represented in those earliest days, with the exception of the Acalephs[1] and Insects only. It is, therefore, not only the plan of the four great types which must have been adopted then, the manner in which these plans were to be executed, the systems of form under which these structures were to be clothed, even the ultimate details of structure which in different genera bear definite relations to those of other genera; the mode of differentiation of species, and the nature of their relations to the surrounding media, must likewise have been determined, as the character of the classes is as well defined as that of the four great branches of the animal kingdom, or that of the families, the genera, and the species. Again, the first representatives of each class stand in definite relations to their successors in later

[1] Acalephs have been found in the Jurassic Limestone of Solenhofen; their absence in other formations may be owing simply to the extraordinary softness of their body. Insects are known as early as the Carboniferous Formation, and may have existed before.

periods, and as their order of apparition corresponds to the various degrees of complication in their structure, and forms natural series closely linked together, this natural gradation must have been contemplated from the very beginning. There can be the less doubt upon this point, as man, who comes last, closes in his own cycle a series, the gradation of which points from the very beginning to him as its last term. I think it can be shown by anatomical evidence that man is not only the last and highest among the living beings, for the present period, but that he is the last term of a series beyond which there is no material progress possible upon the plan upon which the whole animal kingdom is constructed, and that the only improvement we may look to upon earth, for the future, must consist in the development of man's intellectual and moral faculties.[1]

The question has been raised of late how far the oldest fossils known may truly be the remains of the first inhabitants of our globe. No doubt extensive tracts of fossiliferous rocks have been intensely altered by plutonic agencies, and their organic contents so entirely destroyed, and the rocks themselves so deeply metamorphosed, that they resemble now more closely eruptive rocks even than stratified deposits. Such changes have taken place again and again up to comparatively recent periods, and upon a very large scale. Yet there are entire continents, North America, for instance, in which the palæozoic rocks have undergone little, if any, alteration, and where the remains of the earliest representatives of the animal and vegetable kingdoms are as well preserved as in later formations. In such deposits the evidence is satisfactory that a variety of animals belonging to different classes of the great branches of the animal kingdom have existed simultaneously from the beginning; so that the assumption of a successive introduction of these types upon earth is flatly contradicted by well established and well known facts.[2] Moreover, the remains found in the oldest deposits, are everywhere closely allied to one another. In Russia, in Sweden, in Bohemia, and in various other parts of the world, where these oldest formations have been altered upon a more or less extensive scale, as well as in North America, where they have undergone little or no change, they present the same general character, that close correspondence in their structure and in the combination of their families, which shows them to have belonged to contemporaneous faunæ. It would, therefore, seem that even where metamorphic rocks prevail, the traces of the earliest inhabitants of this globe have not been entirely obliterated.

[1] AGASSIZ, (L.,) An Introduction to the Study of Natural History, New York, 1847, 8vo. p. 57.

[2] AGASSIZ, (L.,) The Primitive Diversity and Number of Animals in Geological Times, Amer. Journ. of Science and Arts, 2d ser., vol. 17, 1854, p. 309.

SECTION VIII.

THE GRADATION OF STRUCTURE AMONG ANIMALS.

There is not only variety among animals and plants; they differ also as to their standing, their rank, their superiority or inferiority when compared to one another. But this rank is difficult to determine; for while, in some respects, all animals are equally perfect, as they perform completely the part assigned to them in the general economy of nature,[1] in other respects there are such striking differences between them, that their very agreement in certain features points at their superiority or inferiority in regard to others.

This being the case, the question first arises, Do all animals form one unbroken series from the lowest to the highest? Before the animal kingdom had been studied so closely as it has been of late, many able writers really believed that all animals formed but one simple continuous series, the gradation of which Bonnet has been particularly industrious in trying to ascertain.[2] At a later period, Lamarck[3] has endeavored to show further, that in the complication of their structure, all the classes of the animal kingdom represent only successive degrees, and he is so thoroughly convinced that in his systematic arrangement classes constitute one gradual series, that he actually calls the classes "degrees of organization." DeBlainville[4] has in the main followed in the steps of Lamarck, though he does not admit quite so simple a series, for he considers the Mollusks and Articulates as two diverging branches ascending from the Radiata, to converge again and unite in the Vertebrata. But since it is now known how the great branches of the animal kingdom may be circumscribed,[5] notwithstanding a few doubtful points; since it is now known how

[1] EHRENBERG, (C. G.,) Das Naturreich des Menschen, oder das Reich der willensfreien beseelten Naturkörper, in 29 Classen übersichtlich geordnet, Berlin, 1835, folio, (1 sheet).

[2] BONNET, (CH.,) Considérations sur les corps organisés, Amsterdam, 1762, 2 vols. 8vo. — Contemplations de la Nature, Amsterdam, 1764–65, 2 vols. 8vo. — Palingénésie philosophique, Genève, 1769, 2 vols. 8vo.

[3] LAMARCK, (J. B. DE,) Philosophie zoologique, Paris, 1809, 2 vols. 8vo.

[4] BLAINVILLE, (H. D. DE,) De l'Organisation des Animaux, Paris, 1822, 1 vol. 8vo.

[5] BLUMENBACH, (J. FR.,) Handbuch der vergleichenden Anatomie, Göttingen, 1824, 1 vol. 8vo.; Engl. by W. LAWRENCE, London, 1827, 1 vol. 8vo. — CUVIER, (G.,) Leçons d'Anatomie comparée, rec. et publ. par MM. Duméril et Duvernoy, Paris, 1800–1805, 5 vols. 8vo.; 2de édit., rev. par MM. F. G. Cuvier et Laurillard, Paris, 1836–39, 10 vols. 8vo. — CUVIER, (G.,) Le Règne animal distribué d'après son organisation, Paris, 1817, 4 vols. 8vo.;

most classes should be characterized, and what is their respective standing; since every day brings dissenting views, respecting the details of classification, nearer together, the supposition that all animals constitute one continuous gradated series, can be shown to be contrary to nature. Yet the greatest difficulty in this inquiry, is to weigh rightly the respective standing of the four great branches of the whole animal kingdom; for, however plain the inferiority of the Radiata may seem, when compared with the bulk of the Mollusks or Articulata, or still more evident when contrasted with the Vertebrata, it must not be forgotten, that the structure of most Echinoderms is far more complicated than that of any Bryozoon or Ascidian of the type of Mollusks, or that of any Helminth, of the type of Articulata, and, perhaps, even superior to that of the Amphioxus among Vertebrata. These facts are so well ascertained, that an absolute superiority or inferiority of one type over the other must be unconditionally denied. As to a relative superiority or inferiority however, determined by the bulk of evidence, though it must be conceded that the Vertebrata rank above the three other types, the question of the relative standing of Mollusks and Articulata seems rather to rest upon a difference in the tendency of their whole organization, than upon a real gradation in their structure; concentration being the prominent trait of the structure of Mollusks, while the expression 'outward display' would more naturally indicate that of Articulata, and so it might seem as if Mollusks and Articulata were standing on nearly a level with one another, and as much

2de édit. 1829–30, 5 vols. 8vo.; 3e édit. illustrée 1836 et suiv; Engl. Trans. by GRIFFITH, London, 1824, 9 vols. 8vo. — MECKEL, (J. F.,) System der vergleichenden Anatomie, Halle, 1821–31, 6 vols. 8vo.; French Transl., Paris, 1829–38, 10 vols. 8vo. — TREVIRANUS, (G. R.,) Biologie, oder Philosophie der lebenden Natur, Göttingen, 1802–16, 6 vols. 8vo. — Die Erscheinungen und Gesetze des organischen Lebens, Bremen, 1831–37, 5 vols. 8vo. — DELLE CHIAJE, Istituzioni d'Anatomia e Fisiologia comparata, Napoli, 1832, 8vo. — CARUS, (C. G.,) Lehrbuch der vergleichenden Anatomie, Leipzic, 1834, 2 vols., 4to., fig. 2d edit.; Grundsätze der vergleichenden Anatomie, Dresden, 1828, 8vo.; Engl. by R. J. GORE, Bath, 1827, 2 vols. 8vo. Atlas. — CARUS, (C. G.,) and OTTO, (A. W.) Erläuterungstafeln zur vergleichenden Anatomie, Leipzic, 1826–40, fol. — WAGNER, (R.,) Lehrbuch der vergleichenden Anatomie, Leipzic, 1834–35, 2 vol. 8vo.; Engl. by A. TULK, London, 1844, 1 vol. 8vo.; 2d edit. Lehrbuch der Zootomie, Leipzic, 1843–44, 1 vol. 8vo., 2d vol. by FREY and LEUCKARDT; Icones anatomicæ, Leipzig, 1841, fol. — GRANT, (R. E.) Outlines of Comparative Anatomy, London, 1835, 1 vol. fol. — JONES, (RYMER,) A General Outline of the Animal Kingdom, London, 1838–39, 1 vol. 8vo. fig.; 2d edit. 1854. — TODD, (R. B.,) Cyclopedia of Anatomy and Physiology, London, 1835–52, 4 vol. 8vo. fig. — AGASSIZ, (L.,) and GOULD, (A. A.,) Principles of Zoölogy, Boston, 1 vol. 8vo., 2d edit. 1851. — OWEN, (R.,) Lectures on the Invertebrate Animals, London, 1843, 1 vol. fig.; 2d edit. 1855. — Lectures on the Comparative Anatomy of the Vertebrate Animals, Fishes, London, 1846, 1 vol. 8vo. fig. — SIEBOLD, (C. TH. v.,) und STANNIUS, (HERM.,) Lehrbuch der vergleichenden Anatomie, Berlin, 1845–46, 2 vol. 8vo.; 2d edit. 1855; Engl. Trans. by W. J. BURNETT, Boston, 1854. — BERGMANN, (C.,) und LEUCKARDT, (R.,) Vergleichende Anatomie und Physiologie, Stuttgardt, 1852, 1 vol. 8vo. fig.

above Radiata, as both stand below Vertebrata, but constructed upon plans expressing different tendencies. To appreciate more precisely these most general relations among the great types of the animal kingdom, will require deeper investigations into the character of their plan of structure than have been made thus far.[1] Let, however, the respective standing of these great divisions be what it may; let them differ only in tendency, or in plan of structure, or in the height to which they rise, admitting their base to be on one level or nearly so, so much is certain, that in each type there are representatives exhibiting a highly complicated structure and others which appear very simple. Now, the very fact that such extremes may be traced, within the natural boundaries of each type, shows that in whatever manner these great types are supposed to follow one another in a single series, the highest representative of the preceding type must join on to the lowest representative of the following, thus bringing necessarily together the most heterogeneous forms.[2] It must be further evident, that in proportion as the internal arrangement of each great type will be more perfected, the greater is likely to appear the difference at the two ends of the series which are ultimately to be brought into connection with those of other series, in any attempt to establish a single series for all animals.

I doubt whether there is a naturalist now living who could object to an arrangement in which, to determine the respective standing of Radiata, Polyps would be placed lowest, Acalephs next, and Echinoderms highest; a similar arrangement of Mollusks would bring Acephala lowest, Gasteropoda next, and Cephalopoda highest; Articulata would appear in the following order: Worms, Crustacea, and Insects, and Vertebrata, with the Fishes lowest, next Reptiles and Birds, and Mammalia highest. I have here purposely avoided every allusion to controverted points. Now if Mollusks were to follow Radiata in a simple series, Acephala should join on to the Echinoderms; if Articulata, Worms would be the connecting link. We should then have either Cephalopods or Insects, as the highest term of a series beginning with Radiata, followed by Mollusks or by Articulates. In the first case, Cephalopods would be followed by Worms; in the second, Insects by Acephala. Again, the connection with Vertebrata would be made either by Cephalopods, if Articulata were considered as lower than Mollusks, or by Insects, if Mollusks were placed below Articulata. Who does not see, therefore, that in proportion as our knowledge of the true affinities of animals is improving, we accumulate more and more convincing evidence against the idea that the animal kingdom constitutes one simple series?

[1] I regret to be unable to refer here to the contents of a course of lectures which I delivered upon this subject, in the Smithsonian Institution, in 1852. Compare, meanwhile, my paper, On the Differences between Progressive, Embryonic, and Prophetic Types, Proc. Am. Assoc. for 1849, p. 432.

[2] AGASSIZ, (L.,) Animal Morphology, Proc. Am. Assoc. for 1849, p. 415.

The next question would then be: Does the animal kingdom constitute several, or any number of graduated series? In attempting to ascertain the value of the less comprehensive groups, when compared to one another, the difficulties seem to be gradually less and less. It is already possible to mark out with tolerable precision, the relative standing between the classes, though even here we do not yet perceive in all the types the same relations. Among Vertebrata, there can be little if any doubt, that the Fishes are lower than the Reptiles, these lower than Birds, and that Mammalia stand highest; it seems equally evident, that in the main, Insects and Crustacea are superior to Worms, Cephalopods to Gasteropods and Acephala and Echinoderms to Acalephs and Polypi. But there are genuine Insects, the superiority of which over many Crustacea, would be difficult to prove; there are Worms which in every respect appear superior to certain Crustacea; the structure of the highest Acephala seems more perfect than that of some Gasteropods, and that of the Halcyonoid Polyps more perfect than that of many Hydroids. Classes do, therefore, not seem to be so limited in the range of their characters, as to justify in every type a complete serial arrangement among them. But when we come to the orders, it can hardly be doubted that the gradation of these natural divisions among themselves in each class, constitutes the very essence of this kind of groups. As a special paragraph is devoted to the consideration of the character of orders in my next chapter, I need not dwell longer upon this point here.[1] It will be sufficient for me to remark now, that the difficulties geologists have met with, in their attempts to compare the rank of the different types of animals and plants with the order of their succession in different geological periods, has chiefly arisen from the circumstance, that they have expected to find a serial gradation, not only among the classes of the same type, where it is only incomplete, but even among the types themselves, between which such a gradation cannot be traced. Had they limited their comparisons to the orders which are really founded upon gradation, the result would have been quite different; but to do this requires more familiarity with Comparative Anatomy, with Embryology and with Zoölogy proper, than can naturally be expected of those, the studies of which are chiefly devoted to the investigation of the structure of our globe.

To appreciate fully the importance of this question of the gradation of animals, and to comprehend the whole extent of the difficulties involved in it, a superficial acquaintance with the perplexing question of the order of succession of animals in past geological ages, is by no means sufficient; a complete familiarity with the many attempts which have been made to establish a correspondence between the two, and with all the crudities which have been published upon this subject, might dispel

[1] See Chap. II.

every hope to arrive at any satisfactory result upon this subject, did it not appear now, that the inquiry must be circumscribed within different limits, to be conducted upon its true ground. The results to which I have already arrived, since I have perceived the mistake under which investigators have been laboring thus far, in this respect, satisfy me that the point of view under which I have presented the subject here is the true one, and that in the end, the characteristic gradation exhibited by the orders of each class, will present the most striking correspondence with the character of the succession of the same groups in past ages, and afford another startling proof of the admirable order and gradation which have been established from the very beginning, and maintained through all times in the degrees of complication of the structure of animals.

SECTION IX.

RANGE OF GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

The surface of the earth being partly formed by water and partly by land, and the organization of all living beings standing in close relation to the one or the other of these mediums, it is in the nature of things, that no single species, either of animals or plants, should be uniformly distributed over the whole globe. Yet there are some types of the animal, as well as of the vegetable kingdom, which are equably distributed over the whole surface of the land, and others which are as widely scattered in the sea, while others are limited to some continent or some ocean, to some particular province, to some lake, nay, to some very limited spot of the earth's surface.[1]

As far as the primary divisions of animals are concerned, and the nature of the medium to which they are adapted does not interfere, representatives of the four great branches of the animal kingdom are everywhere found together. Radiata, Mollusks, Articulata, and Vertebrata occur together in every part of the ocean, in the Arctics, as well as under the equator, and near the southern pole as far as man has penetrated; every bay, every inlet, every shoal is haunted by them. So univer-

[1] The human race affords an example of the wide distribution of a terrestrial type; the Herring and the Mackerel families have an equally wide distribution in the sea. The Mammalia of New Holland show how some families may be limited to one continent; the family of Labyrinthici of the Indian Ocean, how fishes may be circumscribed in the sea, and that of the Goniodonts of South America in the fresh waters. The Chaca of Lake Baikal is found nowhere else; this is equally true of the Blindfish (Amblyopsis) of the Mammoth Cave, and of the Proteus of the caverns of Carinthia.

sal is this association, not only at present but in all past geological ages, that I consider it as a sufficient reason to expect, that fishes will be found in those few fossiliferous beds of the Silurian System, in which thus far they have not yet been found.[1] Upon land, we find equally everywhere Vertebrata, Articulata, and Mollusks, but no Radiata, this whole branch being limited to the waters; but as far as terrestrial animals extend, we find representatives of the other three branches associated, as we find them all four in the sea. Classes have already a more limited range of distribution. Among Radiata, the Polypi, Acalephs, and Echinoderms[2] are not only all aquatic, they are all marine, with a single exception,[3] the genus Hydra, which inhabits fresh waters. Among Mollusks,[4] the Acephala are all aquatic, but partly marine and partly fluviatile, the Gasteropoda partly marine, partly fluviatile and partly terrestrial, while all Cephalopoda are marine. Among Articulata,[5] the Worms are partly marine, partly fluviatile, and partly terrestrial, while many are internal

[1] See, above, Sect. 7.

[2] For the geographical distribution of Radiata, consult: DANA, (J. D.,) Zoophytes. United States Exploring Expedition, under the command of Ch. Wilkes, U. S. N., Philadelphia, 1846, 1 vol. 4to. Atlas fol. — MILNE-EDWARDS et HAIME, (JUL.,) Recherches sur les Polypiers, Ann. Sc. Nat. 3e sér. vol. 9–18, Paris, 1848–52, 8vo. — ESCHSCHOLTZ, (FR.,) System der Acalephen, Berlin, 1829, 4to. fig. — LESSON, (R. PR.,) Histoire naturelle des Zoophytes, Acalèphes, Paris, 1843, 1 vol. 8vo. fig. — KÖLLIKER, (A.,) Die Schwimmpolypen und Siphonophoren von Messina, Leipzic, 1853, 1 vol. fol. fig. — MÜLLER, (J.,) und TROSCHEL, (F. H.,) System der Asteriden, Braunschweig, 1842, 8vo. fig. — AGASSIZ, (L.,) Catalogue raisonné des familles, des genres et des espèces de la Classe des Echinodermes, Ann. des Sc. Nat. 3e sér. vol. 6–8, Paris, 1847, 8vo.

[3] I need hardly say in this connection that the so-called fresh-water Polyps, Alcyonella, Plumatella, etc., are Bryozoa, and not true Polyps.

[4] For the geographical distribution of Mollusks, consult: LAMARCK, (J. B. DE,) Histoire naturelle des Animaux sans vertèbres, Paris, 1815–22, 7 vols. 8vo.; 2de édit. augmentée de notes par MM. DESHAYES and MILNE-EDWARDS, Paris, 1835–43, 10 vols. 8vo. — FERUSSAC, (J. B. L. DE,) Histoire naturelle des Mollusques terrestres et fluviatiles. Paris, 1819 et suiv, 4to. fig. fol., continuée par DESHAYES. — FERUSSAC, (J. B. L. DE,) et SANDERRANG, (A.,) Histoire naturelle des Aplysiens, Paris, 1828, 4to. fig. fol. — FERUSSAC, (J. B. L. DE,) et D'ORBIGNY, (A.,) Monographie des Céphalopodes cryptodibranches, Paris, 1834–43, fol. — MARTINI, (F. H. W.,) und CHEMNITZ, (J. H.) Neues systematisches Conchylien-Kabinet, Nürnberg, 1769–95, 11 vols. 4to. fig.; new edit. and continuation by SCHUBERT and A. WAGNER, completed by H. C. KÜSTER, Nürnberg, 11 vols. 4to. fig. — KIENER, (L. C.,) Spécies général et Iconographie des Coquilles vivantes, Paris, 1834, et suiv, 8vo. fig. — REEVE, (Lovell,) Conchologia Iconica; a Complete Repertory of Species of Shells, Pictorial and Descriptive, London, 1843, and foll., 4to. fig. — PFEIFFER, (L.,) Monographia Heliceorum viventium, Leipzig, 1847–48, 8vo. — PFEIFFER, (L.,) Monographia Pneumonopomorum viventium, Cassel, 1852, 8vo., and all the special works on Conchology.

[5] The mode of distribution of free or parasitic Worms, in different parts of the world and in different animals, may be ascertained from: GRUBE, (A. ED.,) Die Familien der Anneliden, Wiegman's Archiv, 1850. I mention this paper in preference to any other work, as it is the only complete list of Annulata; and though the localities are not given, the references may supply the deficiency. — RUDOLPHI, (K. A.,) Entozoorum sive Vermium intestinalium Historia naturalis, Amstelodami, 1808–10, 3 vols.

parasites, living in the cavities or in the organs of other animals; the Crustacea are partly marine and partly fluviatile, a few are terrestrial; the Insects are mostly terrestrial or rather aërial, yet some are marine, others fluviatile, and a large number of those, which in their perfect state live in the air, are terrestrial or even aquatic during their earlier stages of growth. Among Vertebrata[1] the Fishes are all aquatic, but partly marine and partly fluviatile; the Reptiles are either aquatic, or amphibious or terrestrial, and some of the latter are aquatic during the early part of their life; the Birds are all aërial, but some more terrestrial and others more aquatic; finally, the Mammalia though all aërial live partly in the sea, partly in fresh water, but mostly upon land. A more special review might show, that this localization in connection with the elements in which animals live, has a direct reference to peculiarities of structure of such importance, that a close consideration of the habitat of animals within the limits of the classes, might in most cases lead to a very natural classification.[2] But this is true only within the limits of the classes, and even here

8vo. fig. — Entozoorum Synopsis, Berolini, 1819, 8vo. fig. — GURLT, (E. F.,) Verzeichniss der Thiere, bei welchen Entozoen gefunden worden sind, Wiegman's Archiv, 1845, contin. by Creplin in the following No. — DUJARDIN, (FEL.,) Histoire naturelle des Helminthes ou Vers intestinaux, Paris, 1844, 1 vol. 8vo. — DIESING, (C. M.,) Historia Vermium, Vindob. 1850, 2 vols. 8vo. That of Crustacea from MILNE-EDWARDS, Histoire naturelle des Crustacés, Paris, 1834, 3 vols. 8vo. fig. — DANA, (J. D.,) Crustacea. United States Exploring Expedition, under the command of Ch. Wilkes, U. S. N., vol. xiv., Philadelphia, 1852, 2 vols. 4to., atlas, fol. For the geographical distribution of Insects I must refer to the general works on Entomology, as it would require pages to enumerate even the standard works relating to the different orders of this class; but they are mentioned in: PERCHERON, (ACH. R.,) Bibliographie entomologique, Paris, 1837, 2 vols. 8vo. — AGASSIZ, (L.,) Bibliographia Zoologiæ et Geologiæ; a general catalogue of all books, tracts, and memoirs on Zoölogy and Geology, corrected, enlarged, and edited by H. E. STRICKLAND, London, 1848–54, 4 vols. 8vo. (Ray Society).

[1] For the geographical distribution of Fishes, consult: CUVIER, (G.,) and VALENCIENNES, (A.,) Histoire naturelle des Poissons, Paris, 1828–1849, 22 vols. 8vo., fig. — MÜLLER, (J.,) und HENLE, (J.,) Systematische Beschreibung der Plagiostomen, Berlin, 1841, fol. fig. For that of Reptiles: DUMERIL, (A. M. C.,) et BIBRON, (G.,) Erpétologie générale, ou Histoire naturelle complète des Reptiles, Paris, 1834–1855, 9 vols. 8vo. fig. — TSCHUDI, (J. J.,) Classification der Batrachier, Neuchâtel, 1838, 4to. Mém. Soc. Neuch. 2d. vol. — FITZINGER, (L. J.,) Systema Reptilium, Vindobonæ, 1843, 8vo. For that of Birds: GRAY, (G. R.,) The Genera of Birds, illustrated with about 350 plates by D. W. Mitchell, London, 1844–1849, 3 vols. imp. 4to. — BONAPARTE, (C. L.,) Conspectus generum Avium, Lugduni-Batavorum, 1850, and seq. 8vo. For that of Mammalia: WAGNER, (A.,) Die geographische Verbreitung der Säugthiere, Verhandl. der Akad. der Wissensch. in München, Vol. IV. — POMPPER, (Herm.,) Die Säugthiere, Vögel und Amphibien, nach ihrer geographischen Verbreitung tabellarish zusammengestellt, Leipzig, 1841, 4to. — See, also, the annual reports in Wiegman's Archiv, now edited by Troschell; the Catalogues of the British Museum, of the Jardin des Plantes, etc.

[2] AGASSIZ, (L.,) The Natural Relations between Animals and the Elements in which they live. Amer. Jour. of Sc. and Arts, 2d ser., vol. 9, 1850, 8vo., p. 369.

not absolutely, as in some the orders only, or the families only are thus closely related to the elements; there are even natural groups, in which this connection is not manifested beyond the limits of the genera, and a few cases in which it is actually confined to the species. Yet, in every degree of these connections, we find that upon every spot of the globe, it extends simultaneously to the representatives of different classes and even of different branches of the animal and vegetable kingdoms; a circumstance which shows that when called into existence, in such an association, these various animals and plants were respectively adapted with all the peculiarities of their kingdom, those of their class, those of their order, those of their genus, and those of their species, to the home assigned to them, and therefore, not produced by the nature of the place, or of the element, or any other physical condition. To maintain the contrary, would really amount to asserting that wherever a variety of organized beings live together, no matter how great their diversity, the physical agents prevailing there, must have in their combined action, the power of producing such a diversity of structures as exists in animals, notwithstanding the close connection in which these animals stand to them, or to work out an intimate relation to themselves in beings, the essential characteristics of which, have no reference to their nature. In other words, in all these animals and plants, there is one side of their organization which has an immediate reference to the elements in which they live, and another which has no such connection, and yet it is precisely this part of the structure of animals and plants, which has no direct bearing upon the conditions in which they are placed in nature, which constitutes their essential, their typical character. This proves beyond the possibility of an objection, that the elements in which animals and plants live (and under this expression I mean to include all that is commonly called physical agents, physical causes, etc.,) cannot in any way be considered as the cause of their existence.

If the naturalists of past centuries have failed to improve their systems of Zoölogy by introducing considerations derived from the habitat of animals, it is chiefly because they have taken this habitat as the foundation of their primary divisions; but reduced to its proper limits, the study of the connection between the structure and the natural home of animals cannot fail to lead to interesting results, among which, the growing conviction that these relations are not produced by physical agents, but determined in the plan ordained from the beginning, will not be the least important.

The unequal limitation of groups of a different value, upon the surface of the earth, produces the most diversified combinations possible, when we consider the mode of association of different families of animals and plants in different parts of the world. These combinations are so regulated that every natural province has a character of its own, as far as its animals and plants are concerned, and such natural

associations of organized beings extending over a wider or narrower area are called *Faunæ* when the animals alone are considered, and *Floræ* when the plants alone are regarded. Their natural limits are far from being yet ascertained satisfactorily everywhere. As the works of Schow and Schmarda may suffice to give an approximate idea of their extent,[1] I would refer to them for further details, and allude here only to the unequal extent of these different faunæ, and to the necessity of limiting them in different ways, according to the point of view under which they are considered, or rather show that, as different groups have a wider or more limited range, in investigating their associations, or the faunæ, we must distinguish between zoölogical realms, zoölogical provinces, zoölogical counties, zoölogical fields, as it were; that is, between zoölogical areas of unequal value over the widest of which range the most extensive types, while in their smaller and smaller divisions, we find more and more limited types, sometimes overlapping one another, sometimes placed side by side, sometimes concentric to one another, but always and everywhere impressing a special character upon some part of a wider area, which is thus made to differ from that of any other part within its natural limits.

These various combinations of smaller or wider areas, equally well defined in different types, has given rise to the conflicting views prevailing among naturalists respecting the natural limits of faunæ; but with the progress of our knowledge these discrepancies cannot fail to disappear. In some respect, every island of the Pacific upon which distinct animals are found, may be considered as exhibiting a distinct fauna, yet several groups of these islands have a common character, which unites them into more comprehensive faunæ, the Sandwich Islands for instance, compared to the Fejees or to New Zealand. What is true of disconnected islands or of isolated lakes is equally true of connected parts of the mainland and of the ocean.

Since it is well known that many animals are limited to a very narrow range in their geographical distribution, it would be a highly interesting subject of inquiry to ascertain what are the narrowest limits within which animals of different types may be circumscribed, as this would furnish the first basis for a scientific consideration of the conditions under which animals may have been created. The time is passed when the mere indication of the continent whence an animal had been obtained, could satisfy our curiosity; and the naturalists who, having an opportunity of ascertaining closely the particular circumstances under which the animals they describe are placed in their natural home, are guilty of a gross disregard of the interest of science when they neglect to relate them. Our knowledge of the geographical distribution of animals would be far more extensive and precise than it

[1] I would also refer to a sketch I have published of the Faunæ in NOTT's and GLIDDON's Types of Mankind, Philadelphia, 1854, 4to., accompanied with a map and illustrations.

is now, but for this neglect; every new fact relating to the geographical distribution of well-known species is as important to science as the discovery of a new species. Could we only know the range of a single animal as accurately as Alphonse DeCandolle has lately determined that of many species of plants, we might begin a new era in Zoölogy. It is greatly to be regretted that in most works, containing the scientific results of explorations of distant countries, only new species are described, when the mere enumeration of those already known might have added invaluable information respecting their geographical distribution. The carelessness with which some naturalists distinguish species merely because they are found in distant regions, without even attempting to secure specimens for comparison, is a perpetual source of erroneous conclusions in the study of the geographical distribution of organized beings, not less detrimental to the progress of science than the readiness of others to consider as identical, animals and plants which may resemble each other closely, without paying the least regard to their distinct origin, and without even pointing out the differences they may perceive between specimens from different parts of the world. The perfect identity of animals and plants living in very remote parts of the globe has so often been ascertained, and it is also so well known how closely species may be allied and yet differ in all the essential relations which characterize species, that such loose investigations are no longer justifiable.

This close resemblance of animals and plants in distant parts of the world is the most interesting subject of investigation with reference to the question of the unity of origin of animals, and to that of the influence of physical agents upon organized beings in general. It appears to me that as the facts point now distinctly to an independent origin of individuals of the same species in remote regions, or of closely allied species representing one another in distant parts of the world, one of the strongest arguments in favor of the supposition that physical agents may have had a controlling influence in changing the character of the organic world, is gone for ever.

The narrowest limits within which certain Vertebrata may be circumscribed, is exemplified, among Mammalia, by some large and remarkable species: the Orang-Outangs upon the Sunda Islands, the Chimpanzee and the Gorilla along the western coast of Africa, several distinct species of Rhinoceros about the Cape of Good Hope, and in Java and Sumatra, the Pinchaque and the common Tapir in South America, and the eastern Tapir in Sumatra, the East Indian and the African Elephant, the Bactrian Camel and the Dromedary, the Llamas, and the different kinds of wild Bulls, wild Goats, and wild Sheep, etc.; among birds by the African Ostrich, the two American Rheas, the Casovary (Dromicejus) of New Holland, and the Emeu (Casuarius galeatus) of the Indian Archipelago, and still more by the different

species of doves confined to particular islands in the Pacific Ocean; among Reptiles, by the Proteus of the cave of Adelsberg in Carinthia, by the Gopher (Testudo Polyphemus Auct.) of our Southern States; among fishes, by the Blind Fish (Amblyopsis spelæus) of the Mammoth Cave. Examples of closely limited Articulata may not be so striking, yet the Blind Crawfish of the Mammoth Cave and the many parasites found only upon or within certain species of animals, are very remarkable in this respect. Among Mollusks, I would remark the many species of land shells, ascertained by Professor Adams to occur only in Jamaica,[1] among the West India Islands, and the species discovered by the United States Exploring Expedition upon isolated islands of the Pacific, and described by Dr. Gould.[2] Even among Radiata many species might be quoted, among Echinoderms as well as among Medusæ and Polypi, which are only known from a few localities; but as long as these animals are not collected with the special view of ascertaining their geographical range, the indications of travellers must be received with great caution, and any generalization respecting the extent of their natural area would be premature as long as the countries they inhabit have not been more extensively explored. It is nevertheless true as established by ample evidence, that within definite limits all the animals occurring in different natural zoölogical provinces are specifically distinct. What remains to be ascertained more minutely is the precise range of each species, as well as the most natural limits of the different faunæ.

SECTION X.

IDENTITY OF STRUCTURE OF WIDELY DISTRIBUTED TYPES.

It is not only when considering the diversification of the animal kingdom within limited geographical areas, that we are called upon in our investigations to admire the unity of plan its most diversified types may exhibit; the identity of structure of these types is far more surprising, when we trace it over a wide range of country, and within entirely disconnected areas. Why the animals and plants of North America should present such a strong resemblance to those of Europe and Northern Asia, while those of Australia are so entirely different from those of Africa and South America under the same latitudes, is certainly a problem of great interest in connec-

[1] ADAMS, (C. B.,) Contributions to Conchology, New York, 1849–50, 8vo. A series of pamphlets, full of original information.

[2] GOULD, (A. A.,) Mollusks, United States Exploring Expedition, under the command of CH. WILKES, U. S. N., 1 vol. 4to. Philadelphia, 1854.

tion with the study of the influence of physical agents upon the character of animals and plants in different parts of the world. North America certainly does not resemble Europe and Northern Asia, more than parts of Australia resemble certain parts of Africa or of South America, and even if a greater difference should be conceded between the latter than between the former, these disparities are in no way commensurate with the difference or similarity of their organized beings, nor in any way rationally dependent one upon the other. Why should the identity of species prevailing in the Arctics not extend to the temperate zone, when many species of this zone, though different, are as difficult to distinguish, as it is difficult to prove the identity of certain arctic species, in the different continents converging to the north, and when besides, those of the two zones mingle to a great extent at their boundaries? Why are the antarctic species not identical with those of the arctic regions? And why should a further increase of the average temperature introduce such completely new types, when even in the Arctics, there are in different continents such strikingly peculiar types (the Rhytina for instance,) combined with those that are identical over the whole arctic area?[1]

It may at first sight seem very natural that the arctic species should extend over the three northern continents converging towards the north pole, as there can be no insuperable barrier to the widest dissemination over this whole area for animals living in a glacial ocean or upon parts of three continents which are almost bound together by ice. Yet the more we trace this identity in detail, the more surprising does it appear, as we find in the Arctics as well as everywhere else, representatives of different types living together. The arctic Mammalia belonging chiefly to the families of Whales, Seals, Bears, Weasels, Foxes, Ruminants and Rodents, have, as Mammalia, the same general structure as the Mammalia of any other part of the globe, and so have the arctic Birds, the arctic Fishes, the arctic Articulata, the arctic Mollusks, the arctic Radiata when compared to the representatives of the same types all over our globe. This identity extends to every degree of affinity among these animals and the plants which accompany them; their orders, their families, and their genera as far as they have representatives elsewhere, bear everywhere the same identical ordinal, family, or generic characters; the arctic foxes have the same

[1] I beg not to be misunderstood. I do not impute to all naturalists the idea of ascribing all the differences or all the similarities of the organic world to climatic influences; I wish only to remind them that even the truest picture of the correlations of climate and geographical distribution, does not yet touch the question of origin, which is the point under consideration. Too little attention has thus far been paid to the facts bearing upon the peculiarities of structure of animals in connection with the range of their distribution. Such investigations are only beginning to be made, as native investigators are studying comparatively the anatomy of animals of different continents.

dental formula, the same toes and claws, in fact, every generic peculiarity which characterizes foxes, whether they live in the Arctics, or in the temperate or tropical zone, in America, in Europe, in Africa, or in Asia. This is equally true of the seals or the whales; the same details of structure which characterize their genera in the Arctics reappear in the Antarctics, and the intervening space, as far as their natural distribution goes. This is equally true of the birds, the fishes, etc., etc. And let it not be supposed that it is only a general resemblance. By no means. The structural identity extends to the most minute details in the most intimate structure of the teeth, of the hair, of the scales, in the furrows of the brain, in the ramification of the vessels, in the folds of the internal surface of the intestine, in the complication of the glands, etc., etc., to peculiarities, indeed, which nobody but a professional naturalist, conversant with microscopic anatomy, would ever believe could present such precise and permanent characters. So complete, indeed, is this identity, that were any of these beings submitted to the investigation of a skilful anatomist, after having been mutilated to such an extent that none of its specific characters could be recognized, yet not only its class, or its order, or its family, but even its genus, could be identified as precisely as if it were perfectly well preserved in all its parts. Were the genera few which have a wide range upon the earth and in the ocean, this might be considered as an extraordinary case; but there is no class of animals and plants which does not contain many genera, more or less cosmopolite in their geographical distribution. The number of animals which have a wide distribution is even so great that, as far at least as genera are concerned, it may fairly be said, that the majority of them have an extensive geographical range. This amounts to the most complete evidence that, as far as any of these genera extends in its geographical distribution, animals the structure of which is identical within this range of distribution, are entirely beyond the influence of physical agents, unless these agents have the power, notwithstanding their extreme diversity, within these very same geographical limits, to produce absolutely identical structures of the most diversified types.

It must be remembered here, that there are genera of Vertebrata, of Articulata, of Mollusks, and of Radiata, which occupy the same identical and wide geographical distribution, and that while the structure of their respective representatives is identical over the whole area, as Vertebrata, as Articulata, as Mollusks, as Radiata, they are at the same time built upon the most different plans. I hold this fact to be in itself a complete demonstration of the entire independence of physical agents of the structure of animals, and I may add that the vegetable kingdom presents a series of facts identical with these. This proves that all the higher relations among animals and plants are determined by other causes than mere physical influences.

While all the representatives of the same genus are identical in structure,[1] the different species of one genus differ only in their size, in the proportions of their parts, in their ornamentation, in their relations to the surrounding elements, etc. The geographical range of these species varies so greatly, that it cannot afford in itself a criterion for the distinction of species. It appears further, that while some species which are scattered over very extensive areas, occupy disconnected parts of that area, other species closely allied to one another and which are generally designated under the name of representative species, occupy respectively such disconnected sections of these areas. The question then arises, how these natural boundaries assigned to every species are established. It is now generally believed that each species had, in the beginning, some starting point, from which it has spread over the whole range of the area it now occupies, and that this starting point is still indicated by the prevalence or concentration of such species in some particular part of its natural area, which, on that account, is called its centre of distribution or centre of creation, while at its external limits the representatives of such species thin out, as it were, occurring more sparsely and sometimes in a reduced condition.

It was a great progress in our science, when the more extensive and precise knowledge of the geographical distribution of organized beings forced upon its cultivators the conviction, that neither animals nor plants could have originated upon one and the same spot upon the surface of the earth, and hence have spread more and more widely until the whole globe became inhabited. It was really an immense progress which freed science from the fetters of an old prejudice; for now we have the facts of the case before us, it is really difficult to conceive how, by assuming such a gradual dissemination from one spot, the diversity which exists in every part of the globe could ever have seemed to be explained. But even to grant distinct centres of distribution for each species within their natural boundaries, is only to meet the facts half way, as there are innumerable relations between the animals and plants which we find associated everywhere, which must be considered as primitive, and cannot be the result of successive adaptation. And if this be so, it would follow that all animals and plants have occupied, from the beginning, those natural boundaries within which they stand to one another in such harmonious relations.[2] Pines have originated in forests, heaths in heathers, grasses in prairies, bees in hives, herrings in schools, buffaloes in herds, men in nations![3] I see a striking proof that this must have been the case in the circumstance, that representative species, which,

[1] See hereafter, Chap. II. Sect. 5.

[2] AGASSIZ, (L.,) Geographical Distribution of Animals, Christian Examiner, Boston, 1850, 8vo. (March).

[3] AGASSIZ, (L.,) The Diversity of Origin of the Human Races, Christian Examiner, Boston, 1850, 8vo. (February.)

as distinct species, must have had from the beginning a different and distinct geographical range, frequently occupy sections of areas which are simultaneously inhabited by the representatives of other species, which are perfectly identical over the whole area. By way of an example, I would mention the European and the American Widgeon, (*Anas 'Mareca' Penelope* and *A. americana*,) or the American and the European Red-headed Ducks, (*A. ferina* and *A. erythrocephala*,) which inhabit respectively the northern parts of the Old and New World in summer, and migrate further south in these same continents during winter, while the Mallard (*A. Boschas*) and the Scaup Duck (*A. marila*) are as common in North America as in Europe. What do these facts tell: That all these birds originated together somewhere, where they no longer occur, to establish themselves in the end within the limits they now occupy? — or that they originated either in Europe or America, where, it is true, they do not live all together, but at least a part of them? — or that they really originated within the natural boundaries they occupy? I suppose with sensible readers I need only argue the conclusions flowing from the last supposition. If so, the American Widgeon and the American Red-headed Duck originated in America, and the European Widgeon and the European Red-headed Duck in Europe. But what of the Mallard and the Scaup, which are equally common upon the two continents; did they first appear in Europe, or in America, or simultaneously upon the two continents? Without entering into further details, as I have only desired to lay clearly a distinct case before my readers, from which the character of the argument, which applies to the whole animal kingdom, may be fully understood, I say that the facts lead, step by step, to the inference, that such birds as the Mallard and the Scaup originated simultaneously and separately in Europe and in America, and that all animals originated in vast numbers, indeed, in the average number characteristic of their species, over the whole of their geographical area, whether its surface be continuous or disconnected by sea, lakes, or rivers, or by differences of level above the sea, etc. The details of the geographical distribution of animals exhibit, indeed, too much discrimination to admit for a moment that it could be the result of accident, that is, the result of the accidental migrations of the animals or of the accidental dispersion of the seeds of plants. The greater the uniformity of structure of these widely distributed organized beings, the less probable does their accidental distribution appear. I confess that nothing has ever surprised me so much as to see the perfect identity of the most delicate microscopic structures of animals and plants, from the remotest parts of the world. It was this striking identity of structure in the same types, this total independence of the essential characteristics of animals and plants, of their distribution under the most extreme climatic differences known upon our globe, which led me to distrust the belief, then almost universal, that organized beings are influenced by physical causes to a degree which may essentially modify their character.

SECTION XI.

COMMUNITY OF STRUCTURE AMONG ANIMALS LIVING IN THE SAME REGIONS.

The most interesting result of the earliest investigations of the fauna of Australia was the discovery of a type of animals, the Marsupialia, prevailing upon this continental island, which are unknown in almost every other part of the world. Every student of Natural History knows now that there are no *Quadrumana* in New Holland, neither Monkeys, nor Makis: no *Insectivora*, neither Shrews, nor Moles, nor Hedgehogs; no true *Carnivora*,[1] neither Bears, nor Weasels, nor Foxes, nor Viverras, nor Hyenas, nor Wild Cats; no *Edentata*, neither Sloths, nor Tatous, nor Ant-eaters, nor Pangolins; no *Pachyderms*, neither Elephants, nor Hippopotamuses, nor Hogs, nor Rhinoceroses, nor Tapirs, nor Wild Horses; no *Ruminantia*, neither Camels, nor Llamas, nor Deers, nor Goats, nor Sheep, nor Bulls, etc., and yet the Mammalia of Australia are almost as diversified as those of any other continent. In the words of Waterhouse,[2] who has studied them with particular care, "the Marsupialia present a remarkable diversity of structure, containing herbivorous, carnivorous, and insectiverous species; indeed, we find amongst the marsupial animals analogous representations of most of the other orders of Mammalia. The *Quadrumana* are represented by the Phelangers, the *Carnivora* by the Dasyuri, the *Insectivora* by the small Phascogales, the *Ruminantia* by the Kangaroos, and the *Edentata* by the Monotremes. The Cheiroptera are not represented by any known marsupial animals, and the Rodents are represented by a single species only; the hiatus is filled up, however, in both cases, by placental species, for Bats and Rodents are tolerably numerous in Australia, and, if we except the Dog, which it is probable has been introduced by man, these are the only placental Mammalia found in that continent." Nevertheless, all these animals have in common some most striking anatomical characters, which distinguish them from all other Mammalia, and stamp them as one of the most natural groups of that class; their mode of reproduction, and the connection of the young with the mother, are different; so, also, is the structure of their brain, etc.[3]

Now, the suggestion that such peculiarities could be produced by physical agents is for ever set aside by the fact that neither the birds nor the reptiles, nor, indeed, any other animals of New Holland, depart in such a manner from the ordinary char-

[1] Doubts are entertained respecting the origin of the Dingo, the only beast of prey of New Holland.

[2] WATERHOUSE, (G. A.,) Natural History of the Mammalia, London, 1848, 2 vols. 8vo., vol. i., p. 4.

[3] See OWEN, (R.,) Marsupialia in Todd's Cyclopedia of Anat. and Physiol., London, 1841, 8vo., and several elaborate papers by himself and others, quoted there.

acter of their representatives in other parts of the world; unless it could be shown that such agents have the power of discrimination, and may produce, under the same conditions, beings which agree and others which do not agree with those of different continents; not to speak again of the simultaneous occurrence in that same continent of other heterogeneous types of Mammalia, Bats and Rodents, which occur there as well as everywhere else in other continents. Nor is New Holland the only part of the world which nourishes animals highly diversified among themselves, and yet presenting common characters strikingly different from those of the other members of their type, circumscribed within definite geographical areas. Almost every part of the globe exhibits some such group either of animals or of plants, and every class of organized beings contains some native natural group, more or less extensive, more or less prominent, which is circumscribed within peculiar geographical limits. Among Mammalia we might quote further the Quadrumana, the representatives of which, though greatly diversified in the Old as well as in the New World, differ and agree respectively in many important points of their structure; also the Edentata of South America.

Among birds, the Humming Birds, which constitute a very natural, beautiful, and numerous family, all of which are nevertheless confined to America only, as the Pheasants are to the Old World.[1] Among Reptiles, the Crocodiles of the Old World compared to those of America. Among fishes, the family of Labyrinthici, which is confined to the Indian and Pacific Oceans, that of Goniodonts, which is limited to the fresh waters of South America, as that of Cestraciontes to the Pacific. The comparative anatomy of Insects is not sufficiently far advanced to furnish striking examples of this kind; among Insects, however, remarkable for their form, which are limited to particular regions, may be quoted the genus Mormolyce of Java, the Pneumora of the Cape of Good Hope, the Belostoma of North America, the Fulgora of China, etc. The geographical distribution of Crustacea has been treated in such a masterly manner by Dana, in his great work upon the Crustacea of the United States Exploring Expedition, Vol. XIII., p. 1451, that I can only refer to it for numerous examples of localized types of this class, and also as a model how to deal with such subjects. Among Worms, the Peripates of Guiana deserves to be mentioned. Among Cephalopods, the Nautilus in Amboyna. Among Gasteropods, the genus Io in the western waters of the United States. Among Acephala, the Trigonia in New Holland, certain Naiades in the United States, the Aetheria in the Nile. Among Echinoderms, the Pentacrinus in the West Indies, the Culcita in Zanzibar, the Amblypneustes in the Pacific, the Temnopleurus in the Indian Ocean, the Dendraster on the western coast

[1] What are called Pheasants in America do not even belong to the same family as the eastern Pheasants. The American, so-called, Pheasants are genuine Grouses.

of North America. Among Acalephs, the Berenice of New Holland. Among Polypi, the true Fungidæ in the Indian and Pacific Oceans, the Renilla in the Atlantic, etc.

Many more examples might be quoted, were our knowledge of the geographical distribution of the lower animals more precise. But these will suffice to show that whether high or low, aquatic or terrestrial, there are types of animals remarkable for their peculiar structure which are circumscribed within definite limits, and this localization of special structures is a striking confirmation of the view expressed already in another connection, that the organization of animals, whatever it is, may be adapted to various and identical conditions of existence, and can in no way be considered as originating from these conditions.

SECTION XII.

SERIAL CONNECTION IN THE STRUCTURE OF AMIMALS WIDELY SCATTERED UPON THE SURFACE OF OUR GLOBE.

Ever since I have become acquainted with the reptiles inhabiting different parts of the world, I have been struck with a remarkable fact, not yet noticed by naturalists, as far as I know, and of which no other class exhibits such striking examples. This fact is that among Saurians, as well as among Betrachians, there are families, the representatives of which, though scattered all over the globe, form the most natural connected series, in which every link represents one particular degree of development. The Scincoids,[1] among Saurians, are one of these families. It contains about one hundred species, referred by Duméril and Bibron to thirty-one genera, which, in the development of their organs of locomotion, exhibit most remarkable combinations, illustrated in a diagram, on the following page.

Fully to appreciate the meaning of this diagram, it ought to be remembered, that the animals belonging to this family are considered here in two different points of view. In the first place, their zoölogical relations to one another are expressed by the various combinations of the structure of their legs; some having four legs, and these are the most numerous, others only two legs, which are always the hind legs, and others still no legs at all. Again these legs may have only one toe, or two, three, four, or five toes, and the number of toes may vary between the fore and hind legs. The classification adopted here is based upon these characters. In

[1] For the characters of the family, see DUMERIL et BIBRON, Erpétologie générale, vol. 5, p. 511. See also COCTEAU, Etudes sur les Scincoides, Paris, 1836, 4to. fig.

the second place, the geographical distribution is noticed. But it is at once apparent that the home of these animals stands in no relation whatsoever to their zoölogical arrangement. On the contrary, the most remote genera may occur in the same country, while the most closely related may live far apart.

GENERA WITH FOUR LEGS.

With *five* toes to the fore feet, as well as to the hind feet:

- *Tropidophorus*, 1 species, Cochin-China.
- *Scincus*, 1 sp., Syria, North and West Africa.
- *Sphenops*, 1 sp., Egypt.
- *Diploglossus*, 6 sp., West Indies and Brazils.
- *Amphiglossus*, 1 sp., Madagascar.
- *Gongylus*, with 7 sub-genera:
  - *Gongylus*, 2 sp., Southern Europe, Egypt, Teneriffe, Isle de France.
  - *Eumeces*, 11 sp., East and West Indies, South America, Vanikoro, New Ireland, New Guinea, Pacific Islands.
  - *Euprepes*, 13 sp., West coast of Africa, Cape of Good Hope, Egypt, Abyssinia, Seychelles, Madagascar, New Guinea, East Indies, Sunda Islands, Manilla.
  - *Plestiodon*, 5 sp., Egypt, Algiers, China, Japan, United States.
  - *Lygosoma*, 19 sp., New Holland, New Zealand, Java, New Guinea, Timor, East Indies, Pacific Islands, United States.
  - *Leiolopisma*, 1 sp., Mauritius and Manilla.
  - *Tropidolopisma*, 1 sp., New Holland.
- *Cyclodus*, 3 sp., New Holland and Java.
- *Trachysaurus*, 1 sp., New Holland.
- *Ablepharus*, 4 sp., Southeastern Europe, New Holland, Pacific Islands.

With *five* toes to the fore feet and *four* toes to the hind feet: *Campsodactylus*, 1 sp., Bengal.

With *four* toes to the fore feet and *five* toes to the hind feet:
- *Heteropus*, 3 sp., Africa, New Holland, Isle de France.
- *Gymnophthalmus*, 1 sp., W. Indies and Brazil.

With *four* toes to the fore feet and *four* toes to the hind feet:
- *Tetradactylus*, 1 sp., New Holland. The genus Chalcides of the allied family Chalcidioids, exhibits another example of this combination.

With *four* toes to the fore feet and *three* toes to the hind feet: No examples known of this combination.

With *three* toes to the fore feet and *four* toes to the hind feet: Not known.

With *three* toes to the fore feet and *three* toes to the hind feet:
- *Hemiergis*, 1 sp., New Holland.
- *Seps*, 1 sp., S. Europe and N. Africa.
- *Nessia*, 1 sp., Origin unknown.

With *three* toes to the fore feet and *two* toes to the hind feet: Not known.

With *two* toes to the fore feet and *three* toes to the hind feet:
- *Heteromeles*, 1 sp., Algiers.
- *Lerista*, 1 sp., New Holland.

With *two* toes to the fore feet and *two* toes to the hind feet: *Chelomeles*, 1 sp., New Holland.

With *two* toes to the fore feet and *one* toe to the hind feet: *Brachymeles*, 1 sp., Philippine Islands.

With *one* toe to the fore feet and *two* toes to the hind feet: *Brachystopus*, 1 sp., South Africa.

With *one* toe to the fore feet and *one* toe to the hind feet: *Evesia*, 1 sp., Origin unknown.

GENERA WITH ONLY TWO LEGS.

No representatives are known *with fore legs only;* but this structural combination occurs in the allied family of the Chalcidioids. The representatives *with hind legs only,* present the following combinations:—

With *two* toes: *Scelotes,* 1 sp., Cape Good Hope.
With *one* toe: *Propeditus,* 1 sp., Cape Good Hope and New Holland.
Ophiodes, 1 sp., South America.
Hysteropus, 1 sp., New Holland.
Lialis, 1 sp., New Holland.
Dibamus, 1 sp., New Guinea.

GENERA WITHOUT ANY LEGS.

Anguis, 1 sp., Europe, Western Asia, Northern Africa.
Ophiomorus, 1 sp., Morea, Southern Russia, and Algiers.
Acontias, 1 sp., Southern Africa, Cape Good Hope.
Typhlina, 1 sp., Southern Africa, Cape Good Hope.

Who can look at this diagram, and not recognize in its arrangement the combinations of thought? This is so obvious, that while considering it one might almost overlook the fact, that while it was drawn up to classify animals preserved in the Museum of the Jardin des Plantes in Paris, it is in reality inscribed in Nature by these animals themselves, and is only read off when they are brought together, and compared side by side. But it contains an important element for our discussion: the series is not built up of equivalent representatives in its different terms, some combinations being richly endowed, others numbering a few, or even a single genus, and still others being altogether disregarded; such freedom indicates selection, and not the working of the law of necessity.

And if from a contemplation of this remarkable series we turn our attention to the indications relating to the geographical distribution of these so closely linked genera, inscribed after their names, we perceive at once, that they are scattered all over the globe, but not so that there could be any connection between the combinations of their structural characters and their homes. The types without legs are found in Europe, in Western Asia, in Northern Africa, and at the Cape of Good Hope; the types with hind legs only, and with one single toe, at the Cape of Good Hope, in South America, New Holland, and New Guinea; those with two toes at the Cape of Good Hope only. Among the types with four legs the origin of those with but one toe to each foot is unknown, those with one toe in the fore foot and two in the hind foot are from South Africa, those with two toes in the fore foot and one in the hind foot occur in the Philippine Islands, those with two toes to all four feet in New Holland, those with three toes to the hind feet and two to the fore feet

in Algiers and New Holland; none are known with three toes to the fore feet and two to the hind feet. Those with three toes to the four feet inhabit Europe, Northern Africa, and New Holland. There are none with three and four toes, either in the fore feet or in the hind feet. Those with four toes to the four feet live in New Holland; those with five toes to the fore feet and four to the hind feet, in Bengal, and with four toes in the fore feet and five in the hind feet, in Africa, the West Indies, the Brazils, and New Holland. Those with five toes to all four feet have the widest distribution, and yet they are so scattered that no single zoölogical province presents any thing like a complete series; on the contrary, the mixture of some of the representatives with perfect feet with others which have them rudimentary, in almost every fauna, excludes still more decidedly the idea of an influence of physical agents upon this development.

Another similar series, not less striking, may be traced among the Batrachians, for the characters of which I may refer to the works of Holbrook, Tschudi, and Baird,[1] even though they have not presented them in this connection, as the characteristics of the genera will of themselves suggest their order, and further details upon this subject would be superfluous for my purpose, the more so, as I have already discussed the gradation of these animals elsewhere.[2]

Similar series, though less conspicuous and more limited, may be traced in every class of the animal kingdom, not only among the living types, but also among the representatives of past geological ages, which adds to the interest of such series in showing, that the combinations include not only the element of space, indicating omnipresence, but also that of time, which involves prescience. The series of Crinoids, that of Brachiopods through all geological ages, that of the Nautiloids, that of Ammonitoids from the Trias to the Cretaceous formation inclusive, that of Trilobites from the lowest beds up to the Carboniferous period, that of Ganoids through all formations; then again among living animals in the class of Mammalia, the series of Monkeys in the Old World especially, that of Carnivora from the Seals, through the Plantigrades, to the Digitigrades; in the class of Birds, that of the Wading Birds, and that of the Gallinaceous Birds; in the class of Fishes, that of Pleuronectidæ and Gadoids, that of Skates and Sharks; in the class of Insects, that of Lepidoptera from the Tineina to the Papilionina; in the class of Crustacea, that of the Decapods in particular; in the class of Worms, that of the Nudibranchiata or that of the Dorsibran-

[1] Holbrook, (J. E.,) North American Herpetology, Philadelphia, 1842, 4to.; 5th vol. — Tschudi, (J. J.) Classification der Batrachier, Neuchâtel, 1838, 4to. — Baird, (Sp. F.) Revision of the North American Tailed Batrachia, Journal Acad. Nat. Science, of Philadelphia, 2d series, vol. I., 1849, 4to.

[2] Agassiz, (L.,) Twelve Lectures on Comparative Embryology, Boston, 1849, 8vo.; p. 8.

chiata especially; in the class of Cephalopoda, that of the Sepioids; in the class of Gasteropoda, that of the Nudibranchiata in particular; in the class of Acephala, that of the Ascidians and that of the Oysters in the widest sense; in the class of Echinoderms, those of Holothuriæ and Asterioids; in the class of Acalephs, that of the Hydroids; in the class of Polyps, that of the Halcyonoids, of the Atræoids, etc., etc., deserve particular attention, and may be studied with great advantage in reference to the points under consideration. For everywhere do we observe in them, with reference to space and to time, the thoughtful combinations of an active mind. But it ought not to be overlooked, that while some types represent strikingly connected series, there are others in which nothing of the kind seems to exist, and the diversity of which involves other considerations.

SECTION XIII.

RELATION BETWEEN THE SIZE OF ANIMALS, AND THEIR STRUCTURE.

The relation between the size and structure of animals has been very little investigated, though even the most superficial survey of the animal kingdom may satisfy any one, that there is a decided relation between size and structure among them. Not that I mean to assert that size and structure form parallel series, or that all animals of one branch, or even those of the same class or the same order, agree very closely with one another in reference to size. This element of their organization is not defined within those limits, though the Vertebrata, as a whole, are larger than either Articulata, Mollusks, or Radiata; though Mammalia are larger than Birds, Crustacea larger than Insects; though Cetacea are larger than Herbivora, these larger than Carnivora, etc. The true limit at which, in the organization of animals, size acquires a real importance, is that of families, that is, the groups which are essentially distinguished by their form, as if form and size were correlative as far as the structure of animals is concerned. The representatives of natural families are indeed closely similar in that respect; the extreme differences are hardly anywhere tenfold within these limits, and frequently only double. A few examples, selected among the most natural families, will show this. Omitting mankind, on account of the objections which might be made against the idea that it embraces any original diversity, let us consider the different families of Monkeys, of Bats, of Insectivora, of Carnivora, of Rodents, of Pachyderms, of Ruminants, etc., among Birds, the Vultures, the Eagles, the Falcons, the Owls, the Swallows, the Finches, the Warblers, the Humming Birds, the Doves, the Wrens, the Ostriches, the Herons,

the Plovers, the Gulls, the Ducks, the Pelicans; among Reptiles, the Crocodiles, the different families of Chelonians, of Lizards, of Snakes, the Frogs proper, the Toads, etc.; among Fishes, the Sharks and Skates, the Herrings, the Codfishes, the Cyprinodonts, the Chætodonts, the Lophobranchii, the Ostracionts, etc.; among Insects, the Sphingoidæ or the Tineina, the Longicorns or the Coccinellina, the Bomboidæ or the Brachonidæ; among Crustacea, the Cancroidea or the Pinnotheroidæ, the Limuloidæ or the Cypridoidæ, and the Rotifera;[1] among Worms, the Dorsibranchiata or the Naioidæ; among Mollusks, the Stromboidæ or the Buccinoidæ, the Helicinoidæ or the Limnæoidæ, the Chamacea or the Cycladoidæ; among Radiata, the Asterioidæ and the Ophiuroidæ, the Hydroids and the Discophoræ, the Astræoidæ and the Actinioidæ.

Having thus recalled some facts which go to show what are the limits within which size and structure are more directly connected,[2] it is natural to infer, that since size is such an important character of species, and extends distinctly its cycle of relationship to the families or even further, it can as little be supposed to be determined by physical agents as the structure itself with which it is so closely connected, both bearing similar relations to these agents.

Life is regulated by a quantitative element in the structure of all organized beings, which is as fixed and as precisely determined as every other feature depending more upon the quality of the organs or their parts. This shows the more distinctly the presence of a specific, immaterial principle in each kind of animals and plants, as all begin their existence in the condition of ovules of a microscopic size, exhibiting in all a wonderful similarity of structure. And yet these primitive ovules, so identical at first in their physical constitution, never produce any thing different from the parents; all reach respectively, through a succession of unvarying changes, the same final result, the reproduction of a new being identical with the parents. How does it then happen, that, if physical agents have such a powerful influence in shaping the character of organized beings, we see no trace of it in the innumerable instances in which these ovules are discharged in the elements in which they undergo their further development, at a period when the germ they contain,

[1] See DANA's Crustacea, p. 1409 and 1411.

[2] These remarks about the average size of animals in relation to their structure, cannot fail to meet with some objections, as it is well known, that under certain circumstances, man may modify the normal size of a variety of plants and of domesticated animals, and that even in their natural state occasional instances of extraordinary sizes occur. But this neither modifies the characteristic average, nor is it a case which has the least bearing upon the question of origin or even the maintenance of any species, but only upon individuals, respecting which more will be found in Sect. 16. Moreover, it should not be overlooked that there are limits to these variations, and that though animals and plants may be placed under influences conducive to a more or less voluminous growth, yet it is chiefly under the agency of man, that such changes reach their extremes. (See also Sect. 15.)

has not yet assumed any of those more determined characteristics which distinguish the full-grown animal or the perfect plant? Do physicists know a law of the material world which presents any such analogy to these phenomena, that it could be considered as accounting for them?

In this connection it should be further remembered, that these cycles of size characteristic of different families, are entirely different for animals of different types, though living together under identical circumstances.

SECTION XIV.

RELATIONS BETWEEN THE SIZE OF ANIMALS, AND THE MEDIUMS IN WHICH THEY LIVE.

It has just been remarked, that animals of different types, even when living together, are framed in structures of different size. Yet, life is so closely combined with the elements of nature, that each type shows decided relations, within its own limits, to these elements as far as size is concerned.[1] The aquatic Mammalia, as a whole, are larger than the terrestrial ones; so are the aquatic Birds, and the aquatic Reptiles. In families which are essentially terrestrial, the species which take to the water are generally larger than those which remain permanently terrestrial, as for instance, the Polar Bear, the Beaver, the Coypu, and the Capivara. Among the different families of aquatic Birds, those of their representatives which are more terrestrial in their habits are generally smaller than those which live more permanently in water. The same relation is observed in the different families of Insects which number aquatic and terrestrial species. It is further remarkable, that among aquatic animals, the fresh water types are inferior in size to the marine ones; the marine Turtles are all larger than the largest inhabitants of our rivers and ponds, the more aquatic Trionyx larger than the Emyds and among these the more aquatic Chelydra larger than the true Emys, and these generally larger than the more terrestrial Clemmys or the Cistudo. The class of Fishes has its largest representatives in the sea; fresh water fishes are on the whole dwarfs, in comparison to their marine relatives, and the largest of them, our Sturgeons and Salmons, go to the sea. The same relations obtain among Crustacea; to be satisfied of the fact, we need only compare our Crawfishes with the Lobsters, our Apus with Limulus, etc. Among

[1] GEOFFROY ST. HILAIRE, (ISID.,) Recherches zoologiques et physiologiques sur les variations de la taille chez les Animaux et dans les races humaines, Paris, 1831, 4to. — See also my paper upon the Natural Relations between Animals and the Elements, etc., quoted above, p. 32.

Worms, the Earthworms and Leeches furnish a still wider range of comparisons when contrasted with the marine types. Among Gasteropods and Acephala, this obtains to the same extent; the most gigantic Ampullariae and Anodontae are small in comparison to certain Fusus, Voluta, Tritonium, Cassis, Strombus, or to the Tridacna. Among Radiata even, which are all marine, with the exception of the single genus Hydra, this rule holds good, as the fresh water Hydroids are among the smallest Acalephs known.

This coincidence, upon such an extensive scale, seems to be most favorable to the view that animals are modified by the immediate influence of the elements; yet I consider it as affording one of the most striking proofs that there is no causal connection between them. Were it otherwise, the terrestrial and the aquatic representatives of the same family could not be so similar as they are in all their essential characteristics, which actually stand in no relation whatsoever to these elements. What constitutes the Bear in the Polar Bear, is not its adaptation to an aquatic mode of existence. What makes the Whales Mammalia, bears no relation to the sea. What constitutes Earthworms, Leeches, and Eunice members of one class, has no more connection with their habitat, than the peculiarities of structure which unite Man, Monkeys, Bats, Lions, Seals, Beavers, Mice, and Whales into one class. Moreover, animals of different types living in the same element have no sort of similarity, as to size. The aquatic Insects, the aquatic Mollusks fall in with the average size of their class, as well as the aquatic Reptiles and the aquatic Birds, or the aquatic Mammalia; but there is no common average for either terrestrial or aquatic animals of different classes taken together, and in this lies the evidence that organized beings are independent of the mediums in which they live, as far as their origin is concerned, though it is plain that when created they were made to suit the element in which they were placed.

To me these facts show, that the phenomena of life are manifested in the physical world, and not through or by it; that organized beings are made to conquer and assimilate to themselves the materials of the inorganic world; that they maintain their original characteristics, notwithstanding the unceasing action of physical agents upon them. And I confess I cannot comprehend how beings, so entirely independent of these influences, could be produced by them.

SECTION XV.

PERMANENCY OF SPECIFIC PECULIARITIES IN ALL ORGANIZED BEINGS.

It was a great step in the progress of science when it was ascertained that species have fixed characters, and that they do not change in the course of time. But this fact, for which we are indebted to Cuvier,[1] has acquired a still greater importance since it has also been established, that even the most extraordinary changes in the mode of existence and in the conditions under which animals may be placed, have no more influence upon their essential characters than the lapse of time.

The facts bearing upon these two subjects are too well known now to require special illustration. I will, therefore, allude only to a few points, to avoid even the possibility of a misapprehension of my statements. That animals of different geological periods differ specifically, *en masse*, from those of preceding or following formations, is a fact satisfactorily ascertained. Between two successive geological periods, then, changes have taken place among animals and plants. But none of those primordial forms of life, which naturalists call species, are known to have changed during any of these periods. It cannot be denied, that the species of different successive periods are supposed by some naturalists to derive their distinguishing features from changes which have taken place in those of preceding ages; but this is a mere supposition, supported neither by physiological nor by geological evidence, and the assumption that animals and plants may change in a similar manner during one and the same period, is equally gratuitous. On the contrary, it is known by the evidence furnished by the Egyptian monuments, and by the most careful comparison between animals found in the tombs of Egypt with living specimens of the same species obtained in the same country, that there is not the shadow of a difference between them, for a period of about five thousand years. These comparisons, first instituted by Cuvier, have proved, that as far as it has been possible to carry back the investigation, it does not afford the beginning of an evidence that species change in the course of time, if the comparisons be limited to the same great cosmic epoch. Geology only shows that at different periods[2] there have existed

[1] CUVIER, (G.,) Recherches sur les ossements fossiles, etc., Nouv., édit. Paris, 1821, 5 vols., 4to., fig., vol. i., sur l'Ibis, p. cxli.

[2] I trust no reader will be so ignorant of the facts here alluded to, as to infer from the use of the word "period" for different eras and epochs of great length, each of which is characterized by different animals, that the differences these animals exhibit, is in itself evidence of a change in the species. The question is, whether any changes take place during one or any of these periods. It is almost incredible how loosely some people will argue upon

different species; but no transition from those of a preceding into those of the following epoch has ever been noticed anywhere; and the question alluded to here is to be distinguished from that of the origin of the differences in the bulk of species belonging to two different geological eras. The question we are now examining involves only the fixity or mutability of species during one epoch, one era, one period in the history of our globe. And nothing furnishes the slightest argument in this point from a want of knowledge of the facts, even though they seem to reason logically. A distinguished physicist has recently taken up this subject of the immutability of species, and called in question the logic of those who uphold it. I will put his argument into as few words as possible, and show, I hope, that it does not touch the case. "Changes are observed from one geological period to another; species which do not exist at an earlier period are observed at a later period, while the former have disappeared; and though each species may have possessed its peculiarities unchanged for a lapse of time, the fact that when long periods are considered, all those of an earlier period are replaced by new ones at a later period, proves that species change in the end, provided a sufficiently long period of time is granted." I have nothing to object to the statement of facts, as far as it goes, but I maintain that the conclusion is not logical. It is true that species are limited to particular geological epochs; it is equally true that, in all geological formations, those of successive periods are different, one from the other. But because they so differ, does it follow that they have changed, and not been exchanged for, or replaced by others? The length of time taken for the operation has nothing to do with the argument. Granting myriads of years for each period, no matter how many or how few, the question remains simply this: When the change takes place, does it take place spontaneously, under the action of physical agents, according to their law, or is it produced by the intervention of an agency not in that way at work before or afterwards? A comparison may explain my view more fully. Let a lover of the fine arts visit a museum arranged systematically, and in which the works of the different schools are placed in chronological order; as he passes from one room to another, he beholds changes as great as those the palæontologist observes in passing from one system of rocks to another. But because these works bear a closer resemblance as they belong to one or the other school, or to periods following one another closely, would the critic be in any way justified in assuming that the earlier works have changed into those of a later period, or to deny that they are the works of artists living and active at the time of their production? The question about the immutability of species is identical with this supposed case. It is not because species have lasted for a longer or shorter time in past ages, that naturalists consider them as immutable, but because in the whole series of geological ages, taking the entire lapse of time which has passed since the first introduction of animals or plants upon earth, not the slightest evidence has yet been produced that species are actually transformed one into the other. We only know that they are different at different periods, as are works of art of different periods and of different schools; but as long as we have no other data to reason upon than those geology has furnished, to this day, it is as unphilosophical and illogical, because such differences exist, to assume that species do change, and have changed, that is, are transformed, or have been transformed, as it would be to maintain that works of art change in the course of time. We do not know how organized beings have originated, it is true; no naturalist can be prepared to account for their appearance in the beginning, or for their difference in different periods; but enough is known to repudiate the assumption of their transmutation, as it does not explain the facts, and shuts out further attempts at proper investigations. See BADEN POWELL'S Essays, quoted above; p. 412, et seq., and Essay 3d, generally.

favor of their mutability; on the contrary, every modern investigation[1] has only gone to confirm the results first obtained by Cuvier, and his views that species are fixed.

It is something to be able to show by monumental evidence, and by direct comparison, that animals and plants have undergone no change for a period of about five thousand years.[2] This result has had the greatest influence upon the progress of science, especially with reference to the consequences to be drawn from the occurrence in the series of geological formations of organized beings as highly diversified in each epoch as those of the present day;[3] it has laid the foundation for the conviction, now universal among well informed naturalists, that this globe has been in existence for innumerable ages, and that the length of time elapsed since it first became inhabited cannot be counted in years. Even the length of the period to which we belong is still a problem, notwithstanding the precision with which certain systems of chronology would fix the creation of man.[4] There are, however, many circumstances which show that the animals now living have been for a much longer period inhabitants of our globe than is generally supposed. It has been possible to trace the formation and growth of our coral reefs, especially in Florida,[5] with sufficient precision to ascertain that it must take about eight thousand years for one of those coral walls to rise from its foundation to the level of the surface of the ocean. There are, around the southernmost extremity of Florida alone, four such reefs concentric with one another, which can be shown to have grown up, one after the other. This gives for the beginning of the first of these reefs an age of over thirty thousand years; and yet the corals by which they were all built up are the same identical species in all of them. These facts, then, furnish as direct evidence as we can obtain in any branch of physical inquiry, that some, at least, of the species of animals now existing, have been in existence over thirty thousand years, and have not undergone the slightest change during the whole of that period.[6] And yet these

[1] RUNTH, Recherches sur les plantes trouvées dans les tombeaux égyptiens, Ann. des scien. nat., vol. viii., 1826, p. 411.

[2] It is not for me to discuss the degree of reliability of the Egyptian chronology; but as far as it goes, it shows that from the oldest periods ascertained, animals have been what they are now.

[3] See my paper upon The Primitive Diversity, etc., quoted above, p. 25.

[4] NOTT & GLIDDON, Types of Mankind, p. 653.

[5] See my paper upon the Reefs of Florida, soon to be published in the Reports of the United States Coast Survey, extracts of which are already printed in the Report for 1851, p. 145.

[6] Those who feel inclined to ascribe the differences which exist between species of different geological periods to the modifying influence of physical agents, and who look to the changes now going on among the living for the support of such an opinion, and may not be satisfied that the facts just mentioned are sufficient to prove the immutability of species, but may still believe that a longer period of time would yet do what thirty thousand years have not done, I beg leave to refer, for further con-

four concentric reefs are only the most distinct of that region; others, less extensively investigated thus far, lie to the northward; indeed, the whole peninsula of Florida consists altogether of coral reefs annexed to one another in the course of time, and containing only fragments of corals and shells, etc., identical with those now living upon that coast. Now, if a width of five miles is a fair average for one coral reef growing under the circumstances under which the concentric reefs of Florida are seen now to follow one another, and this regular succession should extend only as far north as Lake Ogeechobee, for two degrees of latitude, this would give about two hundred thousand years for the period of time which was necessary for that part of the peninsula of Florida which lies south of Lake Ogeechobee to rise to its present southern extent above the level of the sea, and during which no changes have taken place in the character of the animals of the Gulf of Mexico.

It is very prejudicial to the best interests of science to confound questions that are entirely different, merely for the sake of supporting a theory; yet this is constantly done, whenever the question of the fixity of species is alluded to. A few more words upon this point will, therefore, not be out of place here.

I will not enter into a discussion upon the question whether any species is found identically the same in two successive formations, as I have already examined it at full length elsewhere,[1] and it may be settled finally one way or the other, without affecting the proposition now under consideration; for it is plain, that if such identity could be proved, it would only show more satisfactorily how tenacious species are in their character, to continue to live through all the physical changes which have taken place between two successive geological periods. Again, such identity once proved, would leave it still doubtful whether their representatives in two successive epochs are descendants one of the other, as we have already strong evidence in favor of the separate origin of the representatives of the same species in separate geographical areas.[2] The case of closely allied, but different species occurring in successive periods, yet limited respectively in their epochs, affords, in the course of time, a parallel to the case of closely allied, so-called, representative species occupying different areas in space, which no sound naturalist would suppose now to be derived one from the other. There is no more reason to suppose equally allied species following one another in time to be derived one from the other; and all that has been said

sideration, to the charming song of Chamisso, entitled Tragishe Geschichte, and beginning as follows:

's war Einer dem's zu Herzen ging.

[1] AGASSIZ, (L.,) Coquilles tertiaires réputées identiques avec les espèces vivantes, Nouv. Mém. de la Soc. Helv. des sc. nat. Neuchâtel, 1845, vol. 7, 4to. fig. — AGASSIZ, (L.,) Etudes critiques sur les Mollusques fossiles, Neuchâtel, 1831–45, 4to. fig. — AGASSIZ, (L.,) Monographies d'Echinodermes vivans et fossiles, Neuchâtel, 1838–42, 4 nos., 4to. fig. — AGASSIZ, (L.,) Recherches sur les Poissons fossiles, Neuchâtel, 1833–44, 5 vols., 4to., atlas, fol.

[2] See Sect. 10, where the case of representative species is considered.

in preceding paragraphs respecting the differences observed between species occurring in different geographical areas, applies with the same force to species succeeding each other in the course of time.

When domesticated animals and cultivated plants are mentioned as furnishing evidence of the mutability of species, the circumstance is constantly overlooked or passed over in silence, that the first point to be established respecting them, in order to justify any inference from them against the fixity of species, would be to show that each of them has originated from one common stock, which, far from being the case, is flatly contradicted by the positive knowledge we have that the varieties of several of them, at least, are owing to the entire amalgamation of different species.[1] The Egyptian monuments show further that many of those so-called varieties which are supposed to be the product of time, are as old as any other animals which have been known to man; at all events, we have no tradition, no monumental evidence of the existence of any wild animal older than that which represents domesticated animals, already as different among themselves as they are now.[2] It is, therefore, quite possible that the different races of domesticated animals were originally distinct species, more or less mixed now, as the different races of men are. Moreover, neither domesticated animals nor cultivated plants, nor the races of men, are the proper subjects for an investigation respecting the fixity or mutability of species, as all involve already the question at issue in the premises which are assumed in introducing them as evidence in the case. With reference to the different breeds of our domesticated animals, which are known to be produced by the management of man, as well as certain varieties of our cultivated plants, they must be well distinguished from permanent races, which, for aught we know, may be primordial; for breeds are the result of the fostering care of man; they are the product of the limited influence and control the human mind has over organized beings, and not the free product of mere physical agents. They show, therefore, that even the least important changes which may take place during one and the same cosmic period among animals and plants are controlled by an intellectual power, and do not result from the immediate action of physical causes.

So far, then, from disclosing the effects of physical agents, whatever changes are known to take place in the course of time among organized beings appear as the result of an intellectual power, and go, therefore, to substantiate the view that all the differences observed among finite beings are ordained by the action of the Supreme Intellect, and not determined by physical causes. This position is still more strengthened when we consider that the differences which exist between different races of domesticated animals and the varieties of our cultivated plants, as well

[1] Our fowls, for instance.

[2] NOTT & GLIDDON, Types of Mankind, p. 386.

as among the races of men, are permanent under the most diversified climatic influences; a fact, which the extensive migrations of the civilized nations daily proves more extensively, and which stands in direct contradiction to the supposition that such or similar influences could have produced them.

When considering the subject of domestication, in particular, it ought further to be remembered, that every race of men has its own peculiar kinds of domesticated animals and of cultivated plants, which exhibit much fewer varieties among them in proportion as those races of men have had little or no intercourse with other races, than the domesticated animals of those nations which have been formed by the mixture of several tribes.

It is often stated that the ancient philosophers have solved satisfactorily all the great questions interesting to man, and that modern investigations, though they have grasped with new vigor, and illuminated with new light, all the phenomena of the material world, have added little or nothing in the field of intellectual progress. Is this true? There is no question so deeply interesting to man as that of his own origin, and the origin of all things. And yet antiquity had no knowledge concerning it; things were formerly believed either to be from eternity, or to have been created at one time. Modern science, however, can show, in the most satisfactory manner, that all finite beings have made their appearance successively and at long intervals, and that each kind of organized beings has existed for a definite period of time in past ages, and that those now living are of comparatively recent origin. At the same time, the order of their succession and their immutability during such cosmic periods, show no causal connection with physical agents and the known sphere of action of these agents in nature, but argue in favor of repeated interventions on the part of the Creator. It seems really surprising, that while such an intervention is admitted by all, except the strict materialists, for the establishment of the laws regulating the inorganic world, it is yet denied by so many physicists, with reference to the introduction of organized beings at different successive periods. Does this not rather go to show the imperfect acquaintance of these investigators with the conditions under which life is manifested, and with the essential difference there is between the phenomena of the organic and those of the physical world, than to furnish any evidence that the organic world is the product of physical causes?

SECTION XVI.

RELATIONS BETWEEN ANIMALS AND PLANTS AND THE SURROUNDING WORLD.

Every animal and plant stands in certain definite relations to the surrounding world, some however, like the domestic animals and cultivated plants, being capable of adapting themselves to various conditions more readily than others; but even this pliability is a characteristic feature. These relations are highly important in a systematic point of view, and deserve the most careful attention, on the part of naturalists. Yet, the direction zoölogical studies have taken since comparative anatomy and embryology began to absorb almost entirely the attention of naturalists, has been very unfavorable to the investigation of the habits of animals, in which their relations to one another and to the conditions under which they live, are more especially exhibited. We have to go back to the authors of the preceding century,[1] for the most interesting accounts of the habits of animals, as among modern writers there are few who have devoted their chief attention to this subject.[2] So little, indeed, is its importance now appreciated, that the students of this branch of natural history are hardly acknowledged as peers by their fellow investigators, the anatomists and physiologists, or the systematic zoölogists. And yet, without a thorough knowledge of the habits of animals, it will never be possible to ascertain with any degree of precision the true limits of all those species which descriptive zoölogists have of late admitted with so much confidence in their works. And after all, what does it matter to science that thousands of species more or less, should be described and entered in our systems, if we know nothing about them? A very common defect of the works relating to the habits of animals has no doubt contributed to detract from their value and to turn the attention in other directions: their purely anecdotic character, or the circumstance that they are too frequently made the occasion for narrating personal adventures. Nevertheless, the importance of this

[1] REAUMUR, (R. ANT. DE,) Mémoires pour servir à l'histoire des Insectes, Paris, 1834–42, 6 vol. 4to. fig. — RÖSEL, (A. J.,) Insectenbelustigungen, Nürnberg, 1746–61, 4 vols. 4to. fig. — BUFFON, (G. L. LECLERC DE,) Histoire naturelle générale et particulière, Paris, 1749, 44 vols. 4to. fig.

[2] AUDUBON, (J. J.,) Ornithological Biography, or an Account of the Habits of the Birds of the United States of America, Edinburgh, 1831–49, 5 vols. 8vo. — KIRBY, (W.,) and SPENCE, (W.,) An Introduction to Entomology, London, 1818–26, 4 vols. 8vo. fig. — LENZ, (H. O.,) Gemeinnützige Naturgeschichte, Gotha, 1835, 4 vols. 8vo. — RATZENBURG, (J. TH. CH.,) Die Forst-Insekten, Berlin, 1837–44, 3 vols. 4to. fig., and supplement. — HARRIS, (T. W.,) Report on the Insects injurious to Vegetation, Cambridge, 1841, 1 vol. 8vo.; the most important work on American Insects.

kind of investigation can hardly be overrated; and it would be highly desirable that naturalists should turn again their attention that way, now that comparative anatomy and physiology, as well as embryology, may suggest so many new topics of inquiry, and the progress of physical geography has laid such a broad foundation for researches of this kind. Then we may learn with more precision, how far the species described from isolated specimens are founded in nature, or how far they may be only a particular stage of growth of other species; then we shall know, what is yet too little noticed, how extensive the range of variations is among animals, observed in their wild state, or rather how much individuality there is in each and all living beings. So marked, indeed, is this individuality in many families,—and that of Turtles affords a striking example of this kind,—that correct descriptions of species can hardly be drawn from isolated specimens, as is constantly attempted to be done. I have seen hundreds of specimens of some of our Chelonians, among which there were not two identical. And truly, the limits of this variability constitutes one of the most important characters of many species; and without precise information upon this point for every genus, it will never be possible to have a solid basis for the distinction of species. Some of the most perplexing questions in Zoölogy and Palæontology might long ago have been settled, had we had more precise information upon this point, and were it better known how unequal in this respect different groups of the animal kingdom are, when compared with one another. While the individuals of some species seem all different, and might be described as different species, if seen isolated or obtained from different regions, those of other species appear all as cast in one and the same mould. It must be, therefore, at once obvious, how different the results of the comparison of one fauna with another may be, if the species of one have been studied accurately for a long period by resident naturalists, and the other is known only from specimens collected by chance travellers; or, if the fossil representatives of one period are compared with living animals, without both faunæ having first been revised according to the same standard.[1]

Another deficiency, in most works relating to the habits of animals, consists in the absence of general views and of comparisons. We do not learn from them, how far animals related by their structure are similar in their habits, and how far

[1] In this respect, I would remark that most of the cases, in which specific identity has been affirmed between living and fossil species, or between the fossils of different geological periods, belong to families which present either great similarity or extraordinary variability, and in which the limits of species are, therefore, very difficult to establish. Such cases should be altogether rejected in the investigation of general questions, involving fundamental principles, as are untrustworthy observations always in other departments of science. Compare further, my paper upon the primitive diversity and number of animals, quoted above, in which this point is specially considered.

these habits are the expression of their structure. Every species is described as if it stood alone in the world; its peculiarities are mostly exaggerated, as if to contrast more forcibly with all others. Yet, how interesting would be a comparative study of the mode of life of closely allied species; how instructive a picture might be drawn of the resemblance there is in this respect between species of the same genus and of the same family. The more I learn upon this subject, the more am I struck with the similarity in the very movements, the general habits, and even in the intonation of the voices of animals belonging to the same family; that is to say, between animals agreeing in the main in form, size, structure, and mode of development. A minute study of these habits, of these movements, of the voice of animals cannot fail, therefore, to throw additional light upon their natural affinities.

While I thus acknowledge the great importance of such investigations with reference to the systematic arrangement of animals, I cannot help regretting deeply, that they are not more highly valued with reference to the information they might secure respecting the animals themselves, independently of any system. How much is there not left to study with respect to every species, after it is named and classified. No one can read Nauman's Natural History of the German Birds without feeling that natural history would be much further advanced, if the habits of all other animals had been as accurately investigated and as minutely recorded; and yet that work contains hardly any thing of importance with reference to the systematic arrangement of birds. We scarcely possess the most elementary information necessary to discuss upon a scientific basis the question of the instincts and in general the faculties of animals, and to compare them together and with those of man,[1] not only because so few animals have been thoroughly investigated, but because so much fewer still have been watched during their earlier periods of life, when their faculties are first developing; and yet how attractive and instructive this growing age is in every living being! Who could, for instance, believe for a moment longer that the habits of animals are in any degree determined by the circumstances under which they live, after having seen a little Turtle of the genus Chelydra, still enclosed in its egg-shell, which it hardly fills half-way, with a yolk bag as large as itself hanging from its lower surface and enveloped in its amnios and in its allantois, with the eyes shut, snapping as fiercely as if it could bite without killing itself?[2] Who can watch the Sunfish (Pomotis vulgaris) hovering over its eggs and protecting them for weeks, or the Catfish (Pimelodus Catus) move about with its young, like

[1] SCHEITLIN, (P.,) Versuch einer vollständigen Thierseelenkunde, Stuttgart und Tübingen, 1840, 2 vols. 8vo. — CUVIER, (FRED.,) Résumé analytique des observations sur l'instinct et l'intelligence des animaux, par R. Flourens, Ann. Sc. Nat., 2de sér., vol. 12.

[2] See, Part III., which is devoted to the Embryology of our Turtles.

a hen with her brood, without remaining satisfied that the feeling which prompts them in these acts is of the same kind as that which attaches the Cow to her suckling, or the child to its mother? Who is the investigator, who having once recognized such a similarity between certain faculties of Man and those of the higher animals can feel prepared, in the present stage of our knowledge, to trace the limit where this community of nature ceases? And yet to ascertain the character of all these faculties there is but one road, the study of the habits of animals, and a comparison between them and the earlier stages of development of Man. I confess I could not say in what the mental faculties of a child differ from those of a young Chimpanzee.

Now that we have physical maps of almost every part of the globe,[1] exhibiting the average temperature of the whole year and of every season upon land and sea; now that the average elevation of the continents above the sea, and that of the most characteristic parts of their surface, their valleys, their plains, their table-lands, their mountain systems, are satisfactorily known; now that the distribution of moisture in the atmosphere, the limits of the river systems, the prevailing direction of the winds, the course of the currents of the ocean, are not only investigated, but mapped down, even in school atlases; now that the geological structure of nearly all parts of the globe has been determined with tolerable precision, zoölogists have the widest field and the most accurate basis to ascertain all the relations which exist between animals and the world in which they live.

Having thus considered the physical agents with reference to the share they may have had in calling organized beings into existence, and satisfied ourselves that they are not the cause of their origin, it now remains for us to examine more particularly these relations, as an established fact, as conditions in which animals and plants are placed at the time of their creation, within definite limits of action and reaction between them; for though not produced by the influence of the physical world, organized beings live in it, they are born in it, they grow up in it, they multiply in it, they assimilate it to themselves or feed upon it, they have even a modifying influence upon it within the same limits, as the physical world is subservient to every manifestation of their life. It cannot fail, therefore, to be highly interesting and instructive to trace these connections, even without any reference to the manner in which they were established, and this is the proper sphere of investigation in the study of the habits of animals. The behavior of each kind towards its fellow-beings, and with reference to the conditions of existence in which it is placed, constitutes a field of inquiry of the deepest interest, as extensive as it is

[1] BERGHAUS, Physikalischer Atlas, Gotha, 1838 et seq., fol. — JOHNSTON, (ALEX. KEITH,) Physical Atlas of Natural Phenomena, Edinburgh, 1848, 1 vol. fol.

complicated. When properly investigated, especially within the sphere which constitutes more particularly the essential characteristics of each species of animals and plants, it is likely to afford the most direct evidence of the unexpected independence of physical influences of organized beings, if I mistake not the evidence I have myself been able to collect. What can there be more characteristic of different species of animals than their motions, their plays, their affections, their sexual relations, their care of their young, the dependence of these upon their parents, their instincts, etc., etc.; and yet there is nothing in all this which depends in the slightest degree upon the nature or the influence of the physical conditions in which they live. Even their organic functions are independent of these conditions to a degree unsuspected, though this is the sphere of their existence which exhibits the closest connections with the world around.

Functions have so long been considered as the test of the character of organs, that it has almost become an axiom in comparative anatomy and physiology, that identical functions presuppose identical organs. Most of our general works upon comparative anatomy are divided into chapters according to this view. And yet there never was a more incorrect principle, leading to more injurious consequences, more generally adopted. That naturalists should not long ago have repudiated it, is the more surprising as every one must have felt again and again how unsound it is. The organs of respiration and circulation of fishes afford a striking example. How long have not their gills been considered as the equivalent of the lungs of the higher Vertebrata, merely because they are breathing organs; and yet these gills are formed in a very different way from the lungs; they bear very different relations to the vascular system; and it is now known that they may exist simultaneously with lungs, as in some full-grown Batrachians, and, in the earlier embryonic stages of development, in all Vertebrata. There can no longer be any doubt now, that they are essentially different organs, and that their functions afford no test of their nature and cannot constitute an argument in favor of their organic identity. The same may be said of the vascular system of the fishes. Cuvier[1] described their heart as representing the right auricle and the right ventricle, because it propels the blood it contains to the gills, in the same manner as the right ventricle propels the blood to the lungs of the warm blooded animals; yet embryology has taught us that such a comparison based upon the special relations of the heart of fishes, is unjustifiable. The air sacs of certain spiders have also been considered as lungs, because they perform similar respiratory functions, and yet they are only modified tracheæ,[2] which are constructed upon such a peculiar plan, and stand in

[1] CUVIER, (G.,) Règn. Anim., 2de édit., vol. 2, p. 122.

[2] LEUCKARDT, (R.,) Ueber den Bau und die Bedeutung der sogenannten Lungen bei den Arach-

such different relations to the peculiar kind of blood of the Articulata,[1] that no homology can be traced between them and the lungs of Vertebrata, no more than between the so-called lungs of the air breathing Mollusks, whose aërial respiratory cavity is only a modification of the peculiar kind of gills observed in other Mollusks. Examples might easily be multiplied; I will, however, only allude further to the alimentary canal of Insects and Crustacea, with its glandular appendages, formed in such a different way from that of Vertebrata, or Mollusks, or Radiata, to their legs and wings, etc., etc. I might allude also to what has been called the foot in Mollusks, did it not appear like pretending to suppose that any one entertains still an idea that such a name implies any similarity between their locomotive apparatus and that of Vertebrata or Articulata, and yet, the very use of such a name misleads the student, and even some of the coryphees of our science have not freed themselves of such and similar extravagant comparisons, especially with reference to the solid parts of the frame of the lower animals.[2]

The identification of functions and organs was a natural consequence of the prevailing ideas respecting the influence physical agents were supposed to have upon organized beings. But as soon as it is understood, how different the organs may be, which in animals perform the same function, organization is at once brought into such a position to physical agents as makes it utterly impossible to maintain any genetic connection between them. A fish, a crab, a mussel, living in the same waters, breathing at the same source, should have the same respiratory organs, if the elements in which these animals live had any thing to do with shaping their organization. I suppose no one can be so short-sighted, as to assume that the same physical agents acting upon animals of different types, must produce, in each, peculiar organs, and not to perceive that such an assumption implies the very existence of these animals, independently of the physical agents. But this mistake recurs so constantly in discussions upon this and similar topics, that, trivial as it is, it requires to be rebuked.[3] On the contrary, when acknowledging an intellectual conception,

niden, in SIEBOLD und KÖLLIKER's Zeitschrift, f. wiss. Zool., 1849, I., p. 246.

[1] BLANCHARD, (EM.,) De la circulation dans les Insectes, Compt. Rend., 1847, vol. 24, p. 870. — AGASSIZ, (L.,) On the Circulation of the Fluids in Insects, Proc. Amer. Asso., for 1849, p. 140.

[2] CARUS, (C. G.,) Von den Ur-Theilen des Knochen- und Schalengerüstes, Leipzig, 1828, 1 vol., fol., p. 61–89.

[3] I hope the day is not far distant, when zoölogists and botanists will equally disclaim having shared in the physical doctrines more or less prevailing now, respecting the origin and existence of organized beings. Should the time come when my present efforts may appear like fighting against windmills, I shall not regret having spent so much labor in urging my fellow-laborers in a right direction; but at the same time, I must protest now and for ever, against the bigotry spreading in some quarters, which would press upon science, doctrines not immediately flowing from scientific premises, and check its free progress.

as the preliminary step in the existence not only of all organized beings, but of every thing in nature, how natural to find that while diversity is introduced in the plan, in the complication and the details of structure of animals, their relations to the surrounding media are equally diversified, and consequently the same functions may be performed by the most different apparatus!

SECTION XVII.

RELATIONS OF INDIVIDUALS TO ONE ANOTHER.

The relations in which individuals of the same species of animals stand to one another are not less determined and fixed than the relations of species to the surrounding elements, which we have thus far considered. The relations which individual animals bear to one another are of such a character, that they ought long ago to have been considered as proof sufficient that no organized being could ever have been called into existence by another agency than the direct intervention of a reflective mind. It is in a measure conceivable that physical agents might produce something like the body of the lowest kinds of animals or plants, and that under identical circumstances the same thing may have been produced again and again, by the repetition of the same process; but that upon closer analysis of the possibilities of the case, it should not have at once appeared how incongruous the further supposition is, that such agencies could delegate the power of reproducing what they had just called into existence, to those very beings, with such limitations, that they could never reproduce any thing but themselves, I am at a loss to understand. It will no more do to suppose that from simpler structures such a process may end in the production of the most perfect, as every step implies an addition of possibilities not even included in the original case. Such a delegation of power can only be an act of intelligence; while between the production of an indefinite number of organized beings, as the result of a physical law, and the reproduction of these same organized beings by themselves, there is no necessary connection. The successive generations of any animal or plant cannot stand, as far as their origin is concerned, in any causal relation to physical agents, if these agents have not the power of delegating their own action to the full extent to which they have already been productive in the first appearance of these beings; for it is a physical law that the resultant is equal to the forces applied. If any new being has ever been produced by such agencies, how could the successive generations enter, at the time of their birth, into the same relations to these agents, as their

ancestors, if these beings had not in themselves the faculty of sustaining their character, in spite of these agents? Why, again, should animals and plants at once begin to decompose under the very influence of all those agents which have been subservient to the maintenance of their life, as soon as life ceases, if life is limited or determined by them?

There exist between individuals of the same species relations far more complicated than those already alluded to, which go still further to disprove any possibility of causal dependence of organized beings upon physical agents. The relations upon which the maintenance of species is based, throughout the animal kingdom, in the universal antagonism of sex, and the infinite diversity of these connections in different types, have really nothing to do with external conditions of existence; they indicate only relations of individuals to individuals, beyond their connections with the material world in which they live. How, then, could these relations be the result of physical causes, when physical agents are known to have a specific sphere of action, in no way bearing upon this sphere of phenomena?

For the most part, the relations of individuals to individuals are unquestionably of an organic nature, and, as such have to be viewed in the same light as any other structural feature; but there is much, also, in these connections that partakes of a psychological character, taking this expression in the widest sense of the word.

When animals fight with one another, when they associate for a common purpose, when they warn one another in danger, when they come to the rescue of one another, when they display pain or joy, they manifest impulses of the same kind as are considered among the moral attributes of man. The range of their passions is even as extensive as that of the human mind, and I am at a loss to perceive a difference of kind between them, however much they may differ in degree and in the manner in which they are expressed. The gradations of the moral faculties among the higher animals and man are, moreover, so imperceptible, that to deny to the first a certain sense of responsibility and consciousness, would certainly be an exaggeration of the difference between animals and man. There exists, besides, as much individuality, within their respective capabilities, among animals as among men, as every sportsman, or every keeper of menageries, or every farmer and shepherd can testify who has had a large experience with wild, or tamed, or domesticated animals.[1]

This argues strongly in favor of the existence in every animal of an immaterial

[1] See J. E. RIDINGER's various works illustrative of Game Animals, which have appeared under different titles, in Augsburg, from 1729 to 1778.—GEOFFROY ST. HILAIRE, et CUVIER, (FR.,) Histoire naturelle des Mammifères, Paris, 1820–35, 3 vols. fol.—LENZ, (H. O.,) Gemeinnützige Naturgeschichte, Gotha, 1835, 4 vols. 8vo.—BINGLEY, (W.,) Animal Biography, London, 1803, 3 vols. 8vo.

principle similar to that which, by its excellence and superior endowments, places man so much above animals.[1] Yet the principle exists unquestionably, and whether

[1] It might easily be shown that the exaggerated views generally entertained of the difference existing between man and monkeys, are traceable to the ignorance of the ancients, and especially the Greeks, to whom we owe chiefly our intellectual culture, of the existence of the Orang-Outang and the Chimpanzee. The animals most closely allied to man known to them were the Red Monkey, *κῆβος*, the Baboon, *κυνοκέφαλος*, and the Barbary Ape, *πίθηκος*. A modern translation of Aristotle, it is true, makes him say that monkeys form the transition between man and quadrupeds; (ARISTOTELES, Naturgeschichte der Thiere, von DR. F. STRACK, Frankfurt-am-Main, 1816, p. 65;) but the original says no such thing. In the History of Animals, Book 2, Chap. V., we read only, *ἔνια δὲ τῶν ζώων ἐπαμφοτερίζει τὴν φύσιν τῷ τε ἀνθρώπῳ καὶ τοῖς τετράποσιν.* There is a wide difference between "partaking of the nature of both man and the quadrupeds," and "forming a transition between man and the quadrupeds." The whole chapter goes on enumerating the structural similarity of the three monkeys named above with man, but the idea of a close affinity is not even expressed, and still less that of a transition between man and the quadrupeds. The writer, on the contrary, dwells very fully upon the marked differences they exhibit, and knows as well as any modern anatomist has ever known, that monkeys have four hands. *ἔχει δὲ καὶ βραχίονας, ὥσπερ ἄνθρωπος, ... ἰδίους δὲ τοὺς πόδας. εἰσὶ γὰρ οἷον χεῖρες μεγάλαι. Καὶ οἱ δάκτυλοι ὥσπερ οἱ τῶν χειρῶν, ὁ μέγας μακρότατος· καὶ τὸ κάτω τοῦ ποδὸς χειρὶ ὅμοιον, πλὴν ἐπὶ τὸ μῆκος τὸ τῆς χειρὸς ἐπὶ τα ἔσχατα τεῖνον καθάπερ θέναρ. Τοῦτο δὲ ἐπ' ἄκρου σκληρότερον, κακῶς καὶ ἀμυδρῶς μιμούμενον πτέρνην.*

It is strange that these clear and precise distinctions should have been so entirely forgotten in the days of Linnæus that the great reformer in Natural History had to confess, in the year 1746, that he knew no character by which to distinguish man from the monkeys. Fauna Suecica, Præfat. p. 2. "Nullum characterem adhuc eruere potui, unde homo a simia internoscatur." But it is not upon structural similarity or difference alone that the relations between man and animals have to be considered. The psychological history of animals shows that as man is related to animals by the plan of his structure, so are these related to him by the character of those very faculties which are so transcendent in man as to point at first to the necessity of disclaiming for him completely any relationship with the animal kingdom. Yet the natural history of animals is by no means completed after the somatic side of their nature has been thoroughly investigated; they, too, have a psychological individuality, which, though less fully studied, is nevertheless the connecting link between them and man. I cannot, therefore, agree with those authors who would disconnect mankind from the animal kingdom, and establish a distinct kingdom for man alone, as Ehrenberg (Das Naturreich des Menschen, Berlin, 1835, fol.) and lately I. Geoffroy St. Hilaire, (Hist. nat. générale, Paris, 1856, Tome 1, Part 2, p. 167,) have done. Compare, also, Chap. II., where it is shown for every kind of groups of the animal kingdom that the amount of their difference one from the other never affords a sufficient ground for removing any of them into another category. A close study of the dog might satisfy every one of the similarity of his impulses with those of man, and those impulses are regulated in a manner which discloses psychical faculties in every respect of the same kind as those of man; moreover, he expresses by his voice his emotions and his feelings, with a precision which may be as intelligible to man as the articulated speech of his fellow men. His memory is so retentive that it frequently baffles that of man. And though all these faculties do not make a philosopher of him, they certainly place him in that respect upon a level with a considerable proportion of poor humanity. The intelligibility of the voice of animals to one another, and all their actions connected with such calls are also a strong argument of their perceptive power, and of their ability to act spon-

it be called soul, reason, or instinct, it presents in the whole range of organized beings a series of phenomena closely linked together; and upon it are based not only the higher manifestations of the mind, but the very permanence of the specific differences which characterize every organism. Most of the arguments of philosophy in favor of the immortality of man apply equally to the permanency of this principle in other living beings. May I not add, that a future life, in which man should be deprived of that great source of enjoyment and intellectual and moral improvement which result from the contemplation of the harmonies of an organic world, would involve a lamentable loss, and may we not look to a spiritual concert of the combined worlds and all their inhabitants in presence of their Creator as the highest conception of paradise?

SECTION XVIII.

METAMORPHOSES OF ANIMALS.

The study of embryology is of very recent date; the naturalists of the past century, instead of investigating the phenomena accompanying the first formation and growth of animals, were satisfied with vague theories upon reproduction.[1] It is true

taneously and with logical sequence in accordance with these perceptions. There is a vast field open for investigation in the relations between the voice and the actions of animals, and a still more interesting subject of inquiry in the relationship between the cycle of intonations which different species of animals of the same family are capable of uttering, which, as far as I have as yet been able to trace them, stand to one another in the same relations as the different, so-called, families of languages (SCHLEGEL, (FR.,) Ueber die Sprache und Weisheit der Indier, Heidelberg, 1808, 1 vol. 8vo. — HUMBOLDT, (W. v.,) Ueber die Kawi-Sprache, auf der Insel Java, Berlin, 1836–39, 3 vols. 4to. Abh. Ak. d. Wissensch. — STEINTHAL, (H.,) Grammatik, Logik und Psychologie, Berlin, 1855, 1 vol. 8vo.) in the human family. All the *Canina* bark; the howling of the wolves, the barking of the dogs and foxes, are only different modes of barking, comparable to one another in the same relation as the monosyllabic, the agglutinating, and the inflecting languages. The *Felidæ* mew: the roaring of the lion is only another form of the mewing of our cats and the other species of the family. The *Equina* neigh or bray: the horse, the donkey, the zebra, the dow, do not differ much in the scale of their sounds. Our cattle, and the different kinds of wild bulls, have a similar affinity in their intonations; their lowing differs not in kind, but only in the mode of utterance. Among birds, this is, perhaps, still more striking. Who does not distinguish the note of any and every thrush, or of the warblers, the ducks, the fowls, etc., however numerous their species may be, and who can fail to perceive the affinity of their voices? And does this not indicate a similarity also in their mental faculties?

[1] BUFFON, (G. L. LECLERC DE,) Discours sur la nature des Animaux, Genève, 1754, 12mo.; also in his Oeuvres complètes, Paris, 1774–1804, 36 vols. 4to.

the metamorphoses of Insects became very early the subject of most remarkable observations,[1] but so little was it then known that all animals undergo great changes from the first to the last stages of their growth, that metamorphosis was considered a distinguishing character of Insects. The differences between Insects, in that respect, are however already so great, that a distinction was introduced between those which undergo a complete metamorphosis, that is to say, which appear in three successive different forms, as larvæ, pupæ, and perfect insects, and those with an incomplete metamorphosis, or whose larvæ differ little from the perfect insect. The range of these changes is yet so limited in some insects, that it is not only not greater, but is even much smaller than in many representatives of other classes. We may, therefore, well apply the term metamorphosis to designate all the changes which animals undergo, in direct and immediate succession,[2] during their growth, whether these changes are great or small, provided they are correctly qualified for each type.

The study of embryology, at first limited to the investigation of the changes which the chicken undergoes in the egg, has gradually extended to every type of the animal kingdom; and so diligent and thorough has been the study, that the first author who ventured upon an extensive illustration of the whole field, C. E. von Baer, has already presented the subject in such a clear manner, and drawn general conclusions so accurate and so comprehensive, that all subsequent researches in this department of our science, may be considered only as a further development of the facts first noticed by him and of the results he has already deduced from them.[3] It was he who laid the foundation for the most extensive

[1] SWAMMERDAM, (J.,) Biblia Naturæ, sive Historia Insectorum, etc., Lugduni-Batavorum, 1737–38, 3 vols. fol. fig. — REAUMUR, (R. ANT. DE,) Mémoires pour servir à l'Histoire des Insectes, Paris, 1734–42, 6 vol. 4to. fig. — ROESEL VON ROSENHOF, (A. J.,) Insectenbelustigungen, Nürnberg, 1746–61, 4 vols. 4to. fig.

[2] I say purposely, "in direct and immediate succession," as the phenomena of alternate generation are not included in metamorphosis, and consist chiefly in the production of new germs, which have their own metamorphosis; while metamorphosis proper relates only to the successive changes of one and the same germ.

[3] Without referring to the works of older writers, such as DeGraaf, Malpighi, Haller, Wolf, Meckel, Tiedemann, etc., which are all enumerated with many others in BISCHOFF'S article "Entwickelungsgeschichte," in WAGNER'S Handwörterbuch der Physiologie, vol. 1, p. 860, I shall mention hereafter, chiefly those published since, under the influence of Döllinger, this branch of science has assumed a new character: — BAER, (C. E. v.,) Ueber Entwickelungsgeschichte der Thiere, Königsberg, 1828–37, 2 vols. 4to. fig. The most important work yet published. The preface is a model of candor and truthfulness, and sets the merits of Döllinger in a true and beautiful light. As text-books, I would quote, BURDACH, (C. F.,) Die Physiologie als Erfahrungswissenschaft, Leipzig, 1829–40, 6 vols. 8vo.; French, Paris, 1837–41, 9 vols. 8vo. — MÜLLER, (J.,) Handbuch der Physiologie des Menschen, Coblenz, 1843, 2 vols. 8vo. 4th edit.; Engl. by W. BALY, London, 1837, 8vo. — WAGNER, (R.,) Lehrbuch der Physiologie, Leip-

generalizations respecting the mode of formation of animals; for he first discovered, in 1827, the ovarian egg of Mammalia, and thus showed for the first time, that there is no essential difference in the mode of reproduction of the so-called viviparous and oviparous animals, and that man himself is developed in the same manner as the animals. The universal presence of eggs in all animals and the unity of their structure, which was soon afterwards fully ascertained, constitute, in my opinion, the greatest discovery of modern times in the natural sciences.[1]

It was, indeed, a gigantic step to demonstrate such an identity in the material basis of the development of all animals, when their anatomical structure was already known to exhibit such radically different plans in their full-grown state. From that time a more and more extensive investigation of the manner in which the first germ is formed in these eggs, and the embryo develops itself; how its organs grow gradually out of a homogeneous mass; what changes, what complications, what connections, what functions they exhibit at every stage; how in the end the young animal assumes its final form and structure, and becomes a new, independent being, could not fail to be the most interesting subject of inquiry. To ascertain all this, in as many animals as possible, belonging to the most different types of the animal kingdom, became soon the principal aim of all embryological investigations; and it can truly be said, that few sciences have advanced with such astonishing rapidity, and led to more satisfactory results.

For the actual phases of the mode of development of the different types of the animal kingdom, I must refer to the special works upon this subject,[2] no general

zig, 1839–42, 2 vols. 8vo. — VALENTIN, (G.,) Handbuch der Entwickelungsgeschichte, etc., Berlin, 1835, 1 vol. 8vo. — Lehrbuch der Physiologie des Menschen, Braunschweig, 1843, 2 vols. 8vo. — LONGET, (F. A.,) Traité de Physiologie, Paris, 1850, 2 vols. 8vo. — KÖLLIKER, (ALB.,) Microscopische Anatomie des Menschen, Leipzig, 1840–54, 2 vols. 8vo. fig. — See also OWEN's Lectures, etc., SIEBOLD und STANNIUS's Lehrbuch, and CARUS's Morphologie, q. a. p. 27, and p. 18. I might further quote almost every modern text-book on physiology, but most of them are so evidently mere compilations, exhibiting no acquaintance with the subject, that I omit purposely to mention any other elementary works.

[1] BAER, (C. E. a,) De Ovi Mammalium et Hominis Genesi, Königsberg, 1827, 4to., fig. — PURKINJE, (J. E.) Symbolæ ad ovi avium historiam ante incubationem, Lipsiæ, 1830, 4to. fig. — WAGNER, (R.,) Prodromus Historiæ generationis Hominis atque Animalium, etc., Lipsiæ, 1836, 1 vol., fol., fig. — Icones physiologicæ, Lipsiæ, 1839, 4to. fig.

[2] The limited attention, thus far paid in this country to the study of Embryology, has induced me to enumerate more fully the works relating to this branch of science, than any others, in the hope of stimulating investigations in that direction. There exist upon this continent a number of types of animals, the embryological illustration of which would add immensely to the stock of our science; such are the Opossum, the Ichthyoid Batrachians, the Lepidosteus, the Amia, etc., not to speak of the opportunities which thousands of miles of sea-coast, everywhere easily accessible, afford for embryological investigations, from the borders of the Arctics to the Tropics. In connection with Embryology the question of Individuality comes up naturally.

treatise embracing the most recent investigations having as yet been published; and I must take it for granted, that before forming a definite opinion upon the comparisons instituted hereafter between the growth of animals, and the structural gradation among full-grown animals, or the order of succession of the fossils characteristic of different geological periods, the necessary information respecting these changes has been gathered by my readers, and sufficiently mastered to enable them to deal with it freely.

The embryology of Polypi has been very little studied thus far; what we know of the embryonic growth of these animals relates chiefly to the family of Actinoids.[1] When the young is hatched, it has the form of a little club-shaped or pear-shaped body, which soon assumes the appearance of the adult, from which it differs only by having few tentacles. The mode of ramification and the multiplication by buds have, however, been carefully and minutely studied in all the families of this class.[2] Acalephs present phenomena so peculiar, that they are discussed hereafter in a special section. Their young[3] are either polyplike or resemble more immediately

See upon this subject: — LEUCKART, (RUD.,) Ueber den Polymorphismus der Individuen oder die Erscheinung der Arbeitstheilung in der Natur, Giessen, 1851, 4to. — REICHERT, (C. B.,) Die monogene Fortpflanzung, Dorpat, 1852. — HUXLEY, (TH. H.,) Upon Animal Individuality, Ann. and Mag. Nat. Hist. 2d ser., 1852, vol. 9, p. 507. — FORBES, (ED.,) On the supposed Analogy between the Life of an Individual and the Duration of a Species, Ann. and Mag. Nat. Hist., 2d ser., 1852, vol. 10, p. 59. — BRAUN, (AL.,) Das Individuum der Pflanze, q. a. — Betrachtungen über die Erscheinung der Verjüngung in der Natur, Freiburg, 1849, 4to. fig.

[1] SARS, (M.,) Beskrivelser og Jagttagelser over nogle maerkelige eller nye i Havet ved den Bergenske Kyst levende Dyr, etc., Bergen, 1835, 4to. — Fauna littoralis Norvegiæ, Christiania, 1846, fol. fig. — RATHKE, (H.,) in Burdach's Physiologie, vol. 2d, 2d edit. p. 215. — Zur Morphologie, Reisebemerkungen aus Taurien, Riga und Leipzig, 1837, 4to., fig. — AGASSIZ, (L.,) Twelve Lectures, etc., p. 40, et seq.

[2] See DANA'S Zoophytes, and MILNE-EDWARDS et HAIME, Recherches, etc., q. a. p. 31, note 2.

[3] SIEBOLD, (C. TH. E. v.,) Beiträge zur Naturgeschichte der wirbellosen Thiere, Dantzig, 1839, 4to. p. 29. — LOVEN, (S. L.) Beitrag zur Kenntniss der Gattungen Campanularia und Syncoryne, Wiegm. Arch., 1837, p. 249 and 321; French Ann. Sc. n. 2de sér., vol. 15, p. 157. — SARS, (M.,) Beskrivelser, q. a. — Fauna littoralis, q. a. — NORDMANN, (AL. v.,) Sur les changements que l'âge apporte dans la manière d'être des Campanulaires, Comptes-Rendus, 1834, p. 709. — STEENSTRUP, (J.,) Ueber den Generations-Wechsel oder die Fortpflanzung und Entwickelung durch abwechselnde Generationen, Uebers, von LORENZEN, Kopenh. 1842, 8vo., fig.; Engl. by G. BUSK, (Ray Society,) London, 1845, 8vo. — VANBENEDEN, (P. J.,) Mémoire sur les Campanulaires de la côte d'Ostende, etc., Mém. Ac. Brux. 1843, vol. 17, 4to. fig. — Recherches sur l'Embryogénie des Tubulaires, etc., Mém. Ac. Brux. 1844, 4to. fig. — DUJARDIN, (FEL.,) Observations sur un nouveau genre de Médusaires (Cladonema,) provenant de la métamorphose des Syncorynes, Ann. Sc. n. 2de sér. 1843, vol. 20, p. 370. — Mémoire sur le développement des Médusaires et des Polypes Hydraires, Ann. Sc. n. 3e sér., 1845, vol. 4, p. 257. — WILL, (J. G. FR.,) Horæ tergestinæ, Leipzig, 1844, 4to. fig. — FREY, (H.,) und LEUCKART, (R.,) Beiträge zur Kenntniss wirbelloser Thiere, Braunschweig, 1847, 4to. fig. — DALYELL, (SIR J. G.,) Rare

the type of their class. Few multiply in a direct, progressive development. As to Echinoderms, they have for a long time almost entirely escaped the attention of Embryologists, but lately J. Müller has published a series of most important investigations upon this class,[1] disclosing a wonderful diversity in the mode of their develop-

and Remarkable Animals of Scotland, etc., London, 1847, 2 vols. 4to. fig. — FORBES, (ED.,) Monograph of the British Naked-eyed Medusæ, London, 1847, 1 vol. fol. fig. (Ray Society.) — On the Morphology of the Reproductive System of Sertularian Zoophytes, etc., Ann. and Mag. Nat. Hist., 1844, vol. 14, p. 385. — AGASSIZ, (L.,) Twelve Lectures, etc., q. a. — DESOR, (ED.,) Lettre sur la génération médusipare des Polypes Hydraires, Ann. Sc. Nat., 3e sér., 1849, vol. 12, p. 204. — KROHN, (A.,) Bemerkungen über die Geschlechtsverhältnisse der Sertularinen, Müller's Arch., 1843, p. 174. — Ueber die Brut des Cladonema radiatum und deren Entwickelung zum Stauridium, Müller's Arch., 1853, p. 420. — Ueber Podocoryne carnea Sars und die Fortpflanzungsweise ihrer medusenartigen Sprösslinge, Wiegm. Arch., 1851, I., p. 263. — Ueber einige niedere Thiere, Müller's Arch., 1853, p. 137. — Ueber die frühesten Entwickelungsstufen der Pelagia noctiluca, Müller's Arch., 1855, p. 491. — KÖLLIKER, (A.,) Die Schwimmpolypen, etc., q. a. — BUSCH, (W.,) Beobachtungen über Anatomie und Entwickelungsgeschichte einiger wirbelloser Seethiere, Berlin, 1851, 4to. fig. pp. 1, 25 and 30. — GEGENBAUER, KÖLLIKER und MÜLLER, Bericht über einige im Herbste 1852 in Messina angestellte anatomische Untersuchungen, Zeitsch. f. wiss. Zool., vol. 4, p. 299. — GEGENBAUER, (C.,) Ueber die Entwickelung von Doliolum, der Scheibenquallen und von Sagitta, Zeitsch. f. wiss. Zool., 1853, p. 13. — Beiträge zur nähern Kenntniss der Schwimmpolypen (Siphonophoren,) Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 285. — Ueber Diphyes turgida, etc., Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 442. — Ueber den Entwickelungscyclus von Doliolum, etc., Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 283. — FRANTZIUS, (AL. v.,) Ueber die Jungen der Cephea, Zeitsch. f. wiss. Zool., vol. 4, p. 118. — MÜLLER, (J.,) Ueber eine eigenthümliche Meduse des Mittelmeeres und ihren Jugendzustand, Müller's Arch., 1851, p. 272. — SCHULTZE, (M.,) Ueber die männlichen Geschlechtstheile der Campanularia geniculata, Müller's Arch., 1850, p. 53. — HINCKS, (TH.,) Notes on the Reproduction of the Campanulariadæ, etc., Ann. and Mag. Nat. Hist., 2d ser., 1852, vol. 10, p. 81. — Further Notes on British Zoophytes, Ann. and Mag. Nat. Hist., 1853, vol. 15, p. 127. — ALLMAN, (G. J.,) On Hydroids, Rep. Brit. Ass. Adv. Sc., 1852, p. 50. — DERBES, (A.,) Note sur les organes reproducteurs et l'embryogénie du Cyanea chrysaora, Ann. Sc. Nat., 3e sér., 1850, vol. 13, p. 377. — VOGT, (C.,) Ueber die Siphonophoren, Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 522. — HUXLEY, (TH. H.,) On the Anatomy and Affinities of the Family of the Medusæ, Philos. Trans. Roy. Soc., 1849, II., p. 413. — An Account of Researches into the Anatomy of the Hydrostatic Acalephæ, Proc. Brit. Ass. Adv. Sc., 1851, p. 78. — LEUCKARDT, (R.,) Zoologische Untersuchungen, Giessen, 1853–54, 4to. fig. 1st Fasc. — Zur nähern Kenntniss der Siphonophoren von Nizza, Wiegm. Arch., 1854, p. 249. — STIMPSON, (W.,) Synopsis of the Marine Invertebrata of Grand Manan, Smithson. Contrib., 1853, 4to. fig. — LEIDY, (Jos.,) Contributions towards a Knowledge of the Marine Invertebrate Fauna, etc., Journ. Acad. Nat. Sc., Philad., 2d ser. 1855, vol. 3, 4to. fig. — See also below, Sect. 20.

[1] Beskrivelser, etc., p. 37. — Ueber die Entwickelung der Seesterne, Wiegm. Arch., 1844, I., p. 169, fig. — Fauna littoralis, etc., p. 47. — MÜLLER, (J.,) Ueber die Larven u. die Metamorphose der Ophiuren u. Seeigel, Akad. d. Wiss., Berlin, 1848. — Ueber die Larven u. die Metamorphose der Echinodermen, 2te Abh., Ak. d. Wiss., Berlin, 1849. — Ueber die Larven u. die Metamorphose der Holothurien u. Asterien, Ak. d. Wiss., Berlin, 1850. — Ueber die Larven u. die Metamorphose der Echinodermen, 4te Abh., Ak. d. Wiss., Berlin, 1852. — Ueber die Ophiurenlarven des Adriatischen Meeres,

ment, not only in the different orders of the class, but even in different genera of the same family. The larvæ of many have a close resemblance to diminutive Ctenophoræ, and may be homologized with this type of Acalephs.

As I shall hereafter refer frequently to the leading divisions of the animal kingdom, I ought to state here, that I do not adopt some of the changes which have been proposed lately in the limitation of the classes, and which seem to have been pretty generally received with favor. The undivided type of Radiata appears to me as one of the most natural branches of the animal kingdom, and I consider its subdivision into Coelenterata and Echinodermata, as an exaggeration of the anatomical differences observed between them. As far as the plan of their structure is concerned, they do not differ at all, and that structure is throughout homological. In this branch I recognize only three classes, *Polypi*, *Acalephæ*, and *Echinodermata*. The chief difference between the two first lies in the radiating partitions of the main cavity of the Polypi, supporting the reproductive organs; moreover, the digestive cavity in this class consists of an inward fold of the upper aperture of the common sac of the body, while in Acalephs there exist radiating tubes, at least in the *proles medusina*, which extend to the margin of the body where they anastomoze, and the digestive cavity is hollowed out of the gelatinous mass of the body. This is equally true of the Hydroids, the Medusæ proper, and the Ctenophoræ; but nothing of the kind is observed among Polypi. Siphonophoræ, whether their *proles medusina* becomes free or not, and Hydroids agree in having, in the *proles medusina*, simple radiating tubes, uniting into a single circular tube around the margin of the bell-shaped disk. These two groups, constitute together, one natural order, in contradistinction from the Covered-eyed Medusæ, whose radiating tubes ramify towards the margin and form a complicated net of anastomoses. Morphologically, the *proles polypoidea* of the Acalephs, is as completely an Acaleph, as their

Ak. d. Wiss., Berlin, 1852. — Ueber den allgemeinen Plan in der Entwickelung der Echinodermen, Ak. d. Wiss., Berlin, 1853. — Ueber die Gattungen der Seeigellarven, 7te Abh., Ak. d. Wiss., 1855. — Ueber den Canal in den Eiern der Holothurien, Müller's Arch., 1854, p. 60. — French abstracts of these papers may be found in Ann. Sc. Nat., 3e sér., 1852 and '53, vols. 17, 19, and 20; An English account is published by HUXLEY, (TH. H.,) Report upon the Researches of Prof. Müller into the Anatomy and Development of the Echinoderms, Ann. and Mag. Nat. Hist., 2d ser., vol. 8, 1851, p. 1. — KOREN und DANIELSSEN in Nyt Magazin for Naturvid, vol. 5, p. 253, Christiania, 1847; Ann. Sc. Nat. 1847, p. 347. — AGASSIZ, (L.,) Twelve Lectures, etc., p. 13. — DERBES, (A.,) Sur la formation de l'embryon chez l'oursin comestible, Ann. Sc. Nat., 3e sér., vol. 8, p. 80. — BUSH, (W.,) Beobachtungen, etc., q. a. — Ueber die Larve der Comatula, Müller's Arch. 1849, p. 400. — KROHN, (A.,) Ueber die Entwickelung der Seesterne und Holothurien, Müller's Arch., 1853, p. 317. — Ueber die Entwickelung einer lebendig gebährenden Ophiure, Müller's Arch., 1851, p. 338. — Ueber die Larve des Echinus brevispinosus, Müller's Arch., 1853, p. 361. — Beobachtungen über Echinodermenlarven, Müller's Arch., 1854, p. 208. — SCHULTZE, (M.,) Ueber die Entwickelung von Ophiolepis squamata, Müller's Arch., 1852, p. 37.

proles medusina,[1] and whether they separate or remain connected, their structural relations are everywhere the same. A comparison of Hydractinia, which is the most common and the most polymorphous Hydroid, with our common Portuguese Man-of-War (Physalia,) may at once show the homology of their most polymorphous individuals.

The embryology of Mollusks has been very extensively investigated, and some types of this branch are among the very best known in the animal kingdom. The natural limits of the branch itself appear, however, somewhat doubtful. I hold that it must include the Bryozoa,[2] which lead gradually through the Brachiopods[3] and Tunicata to the ordinary Acephala, and I would add, that I have satisfied myself of the propriety of uniting the Vorticellidæ with Bryozoa. On the other hand, the Cephalopods can never be separated from the Mollusks proper, as a distinct branch; the partial segmentation of their yolk no more affords a ground for their separation, than the total segmentation of the yolk of Mammalia would justify their separation from the other Vertebrata. Moreover, Cephalopods are in all the details of their structure homologous with the other Mollusks. The Tunicata are particularly interesting, inasmuch as the simple Ascidians have pedunculated young, which exhibit the most striking resemblance to Boltenia, and form, at the same time, a connecting link with the compound Ascidians.[4] The development of the Lamellibranchiata seems to

[1] I shall show this fully in my second volume. Meanwhile, see my paper on the structure and homologies of Radiata, q. a., p. 20.

[2] ALLMAN, (G. J.,) On the Present State of our Knowledge of the Fresh Water Polyzoa, Proc. Brit. Asso. Adv. Sc., 20th Meet., Edinburgh, 1850, p. 305. — Proc. Irish Ac. 1850, vol. 4, p. 470. — Ibid., 1853, vol. 5, p. 11. — VANBENEDEN, (P. J.,) Recherches sur l'Anatomie, la physiologie et le développement des Bryozoaires qui habitent la côte d'Ostende, Nouv. Mém. Ac. Brux., 1845, vol. 18. — DUMORTIER, (B. C.,) et VANBENEDEN, (P. J.,) Histoire naturelle des Polypes composés d'eau douce, Mém. Ac. Brux., 1850, vol. 16, 4to. fig. — HINCKS, (TH.,) Notes on British Zoophites, with Descriptions of some New Species, Ann. and Mag. Nat. Hist., 2d ser., 1851, vol. 8, p. 353. — EHRENBERG, (C. G.,) Die Infusionsthiere als vollkommene Organismen, Leipzig, 1838, 2 vols. fol. fig. — STEIN, (F.,) Infusionsthiere auf ihre Entwickelungsgeschichte untersucht, Leipzig, 1854, 1 vol. 4to. fig. — FRANTZIUS, (AL. v.,) Analecta ad Ophrydii versatilis historiam naturalem, Vratislav, 1849. — LACHMANN, (C. F. J.,) Ueber die Organization der Infusorien, besonders der Vorticellen, Müller's Arch., 1856, p. 340. Having satisfied myself that the Vorticellidæ are Bryozoa, I would also refer here to all the works on Infusoria in which these animals are considered.

[3] I see from a short remark of Leuckart, Zeitsch. f. wiss. Zool., vol. 7, suppl., p. 115, that he has also perceived the close relationship which exists between Brachiopods and Bryozoa.

[4] SAVIGNY, (J. C.,) Mémoires sur les Anim. sans Vertèbres, etc. q. a. — CHAMISSO, (AD. A.,) De animalibus quibusdam e classe Vermium Linnæana, Fasc. 1, De Salpa, Berol, 1819, 4to., fig. — MEYEN, (F. J.,) Beiträge zur Zoologie, etc., 1st Abth., über Salpen, Nov. Act. Nat. Cur. 1832, vol. 16. — EDWARDS, (H. MILNE,) Observations sur les Ascidies composées des côtes de la Manche, Paris, 1841, 4to., fig. — SARS, (M.,) Beskrivelser, q. a. — Fauna litt., q. a. — VANBENEDEN, (P. J.,) Recherches sur

be very uniform, but they differ greatly as to their breeding, many laying their eggs before the germ is formed, whilst others carry them in their gills until the young are entirely formed.[1] This is observed particularly among the Unios, some of which, however, lay their eggs very early, while others carry them for a longer or shorter time, in a special pouch of the outer gill, which presents the most diversified forms in different genera of this family. Nothing is as yet known of the development of Brachiopods. The Gasteropods[2] exhibit a much greater diversity

l'embryogénie, l'anatomie et la physiologie des Ascidies simples, Mém. Ac. Brux., 1847, vol. 20. — KROHN, (A.,) Ueber die Entwickelung der Ascidien, Müller's Arch., 1852, p. 312. — KÖLLIKER, (A.,) et LÖWIG, De la composition et de la structure des enveloppes des Tuniciers, Ann. Sc. Nat. 3e sér., vol. 5, p. 193. — HUXLEY, (TH. H.,) Observations upon the Anatomy and Physiology of Salpa and Pyrosoma, Philos. Trans. R. Soc., 1851, II., p. 567. — ESCHRICHT, (D. F.,) Anatomisk-physiologiske Undersögelser over Salperne, Kiöb. 1840, fig. — STEENSTRUP, (J.,) Ueber den Generationswechsel, q. a. — VOGT, (C.,) Bilder aus dem Thierleben, Frankfurt a. M., 1852, 8vo. — MÜLLER, (H.,) Ueber Salpen, Zeitsch. f., wiss., Zool., vol. 4, p. 329. — LEUCKART, (R.,) Zoologishe Untersuchungen, Giessen, 1853–54, 4to., fig., 2d Fasc.

[1] CARUS, (C. G.,) Entwickelungsgeschichte unserer Flussmuschel, Leipzig, 1832, 4to., fig. — QUATREFAGES, (ARM. DE,) Sur l'embryogénie des Tarets, Ann. Sc. Nat., 3e sér., 1849, vol. 2, p. 202. — Sur la vie interbranchiale des petites Anodontes, Ann. Sc. Nat., 2de sér., vol. 5, p. 321. — LOVEN, (S. L.,) Om Utvecklingen of Mollusca Acephala, Overs. Vet. Akad. Förhandl. Stockholm, 1849. — Germ. Müller's Arch., 1848, p. 531, and Wiegman's Arch., 1849, p. 312. — PREVOST, (J. L.,) De la génération chez la moule des peintres, Mém. Soc. Phys. Genève, 1825, vol. 3, p. 121. — SCHMIDT, (O.,) Ueber die Entwickelung von Cyclas calyculata Drap. Müller's Arch., 1854, p. 428. — LEYDIG, (F.,) Ueber Cyclas cornea, Müller's Arch., 1855, p. 47.

[2] CARUS, (C. G.,) Von den äussern Lebensbedingungen der weiss- und kaltblütigen Thiere, Leipzig, 1824, 4to., fig. — PREVOST, (J. L.,) De la génération chez le Lymnée, Mém. Soc. Phys., Genève, vol. 5, p. 119. — SARS, (M.,) Zur Entwickelungsgeschichte der Mollusken und Zoophyten, Wiegm. Arch., 1837, I., p. 402; 1840, I., p. 196. — Zusätze zu der von mir gegebenen Dartstellung der Entwickelung der Nudibranchien. Wiegm. Arch. 1845, I. p. 4. — QUATREFAGES, (ARM. DE,) Mémoire sur l'Embryogénie des Planorbes et des Lymnées, Ann. Sc. Nat., 2de sér., vol. 2, p. 107. — VANBENEDEN, (P. J.,) Recherches sur le développement des Aplysies, Ann. Sc. Nat., 2de sér., vol. 15, p. 123. — VANBENEDEN, (P. J.,) et WINDISCHMAN, (CH.,) Recherches sur l'Embryogénie des Limaces, Mém. Ac. Brux., 1841. — JACQUEMIN, (EM.,) Sur le développement des Planorbes, Ann. Sc. Nat., vol. 5, p. 117; Nov. Act. Nat. Cur., vol. 18. — DUMORTIER, (B. C.,) Mémoire sur les évolutions de l'embryon dans les Mollusques Gastéropodes, Mém. Ac. Brux., 1836, vol. 10. — LAURENT, (J. L. M.,) Observations sur le développement de l'oeuf des Limaces, Ann. Sc. Nat., vol. 4, p. 248. — POUCHET, (F. A.,) Sur le développement de l'embryon des Lymnées, Ann. Sc. Nat., 2de sér., vol. 10, p. 63. — VOGT, (C.,) Recherches sur l'Embryologie de l'Actæon, Ann. Sc. Nat., 3e sér., 1846, vol. 6, p. 5. — Beitrag zur Entwickelungsgeschichte eines Cephalophoren, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 162. — SCHULTZE, (M.,) Ueber die Entwickelung des Tergipes lacinulatus, Wiegm. Arch., 1849, I., p. 268. — WARNECK, (N. A.,) Ueber die Bildung und Entwickelung des Embryo bei Gasteropoden, Bull. Soc. Imp., Moscou, 1850, vol. 23, I., p. 90. — SCHMIDT, (O.,) Ueber die Entwickelung von Limax agrestis, Müller's Arch., 1851, p. 278. — LEYDIG, (F.,) Ueber Paludina vivipara, ein Beitrag zur nähern Kenntniss dieses Thieres in embryologischer, anatomischer und histologischer Beziehung, Zeitsch.

in their development than the Lamellibranchiata. Even among the terrestrial and aquatic Pulmonata there are striking differences. Some of the Pectinibranchiata are remarkable for the curious cases in which their eggs are hatched and the young developed, to an advanced state of growth. The cases of Pyrula and Strombus are among the most extraordinary of these organic nests. The embryology of Cephalopods[1] has been masterly illustrated by Kölliker.

There is still much diversity of opinion among naturalists, respecting the limits of Articulata; some being inclined to separate the Arthropoda and Worms as dis-

f. wiss. Zool., 1850, vol. 2, p. 125. — KÖLLIKER, (A.,) q. a., Zeitsch. f. wiss. Zool., vol. 4, p. 333 and 369. — MÜLLER, (J.,) Ueber verschiedene Formen von Seethieren, Müller's Arch., 1854, p. 69. — Ueber Synapta digitata und über die Erzeugung von Schnecken in Holothurien, Berlin, 1852, 4to. fig. — The remarkable case described in this paper, admits of an explanation which Müller has not considered. It is known, that fishes penetrate into the cavity of the body of Holothuriæ, through its posterior opening. (DE BOSSET, Notice, etc., Mém. Soc. Sc. Nat., Neuch., 1839, vol. 2, 4to.) The similarity of Entoconcha mirabilis with the embryonic shell of various species of Littorinæ, such as Lacuna vincta, the development of which I had an opportunity of studying, suggests the possibility, that some species of this family, of which there are many very small ones, select the Synapta as their breeding place and leave it after depositing their eggs, which may become connected with the Synapta, as our Mistletoe or the Orobanche and many other parasitic plants, with the plants upon which they grow. — GEGENBAUER, (C.,) Beiträge zur Entwickelungsgeschichte der Landgasteropoden, Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 371. — Untersuchungen über Pteropoden und Heteropoden, Leipzig, 1855, 1 vol., 4to. fig. — KOREN, (J.,) und DANIELSSEN, (D. C.,) Bitrag til Pectinibranchiernes Udviklingshistorie, Bergen, 1851, 8vo.; French Ann. Sc. Nat., 1852, vol. 18, p. 257, and 1853, vol. 19, p. 89; also Germ. in Wiegm. Arch., 1853, p. 173. — NORDMANN, (AL. V.,) Versuch einer Monographie von Tergipes Edwardsii, St. Petersburg, 1844, 4to. — LEUCKART, (R.,) Zoologische Untersuchungen, Giessen, 1853–54, 4to., fig., 3d Fasc. — HUXLEY, (TH. H.,) On the Morphology of the Cephalous Mollusca, etc., Phils. Trans. R. Soc., 1853, I., p. 29. — HOGG, (JABEZ,) On the Development and Growth of the Watersnail, Quart. Micr. Journ., 1854, p. 91. — REID, (J.,) On the Development of the Ova of the Nudibranchiate Mollusca, Ann. and Mag. Nat. Hist., 1846, vol. 17, p. 377. — CARPENTER, (W. B.,) On the Development of the Embryo of Purpura Lapillus, Quart. Micr. Journ., 1845, p. 17.

[1] KÖLLIKER, (ALB.,) Entwickelungsgeschichte der Cephalopoden, Zurich, 1844, 4to., fig. — VAN-BENEDEN, (P. J.,) Recherches sur l'Embryogénie des Sépioles, N. Mém. Acad. Brux., vol. 14, 1841. — COLDSTREAM, (Z.,) On the Ova of Sepia, Lond. and Ed., Phil. Mag., Oct., 1833. — DUGES, (ANT.,) Sur le développement de l'embryon chez les Mollusques Céphalopodes, Ann. Sc. Nat., vol. 8, p. 107. — RATHKE, (H.,) Perothis, ein neues genus der Cephalopoden, Mém. Ac. St. Petersb., 1834, vol. 2, p. 149. (Is the young of some Loligoid Cephalopod.) MILNE-EDWARDS, (H.,) Observations sur les spermatophores des Mollusques Céphalopodes, etc., Ann. Sc., n., 2de sér., vol. 3, p. 193. — KÖLLIKER, (A.,) Hectocotylus Argonautæ Delle Chiaje und Hect. Tremoctopodis K., die Männchen von Argonauta Argo und Tremoctopus violaceus, Ber. Zool. Anst. Würzburg, 1849, p. 69. — MÜLLER, (H.,) Ueber das Männchen von Argonauta Argo und die Hectocotylen, Zeitsch. f. wiss. Zool., vol. 4, p. 1. — VERANY, (J. B.,) et VOGT, (C.,) Mémoire sur les Hectocotyles et les males de quelques Céphalopodes, Ann. Sc. n., 3e sér., 1852, vol. 17, p. 147. — ROULIN, (F. D.,) De la connaissance qu'ont eue les anciens du bras copulateur chez certains Céphalopodes, Ann. Sc. n., 3e sér., 1852, vol. 17, p. 188. — LEUCKART, (R.,) Zool. Unters. q. a.

tinct branches, while others unite them into one. I confess I cannot see the ground for a distinction. The worm-like nature of the larvæ of the majority of Arthropods and the perfect homology of these larvæ with the true Worms, seem to me to show beyond the possibility of a doubt, that all these animals are built upon one and the same plan, and belong, therefore, to one branch, which contains only three classes, if the principles laid down in my second chapter are at all correct, namely, the Worms, Crustacea, and Insects. As to the Protozoa, I have little confidence in the views generally entertained respecting their nature. Having satisfied myself that Colpoda and Paramecium are the brood of Planariæ, and Opalina that of Distoma, I see no reason, why the other Infusoria, included in Ehrenberg's division Enterodela,[1] should not also be the brood of the many lower Worms, the development of which has thus far escaped our attention. Again, a comparison of the early stages of development of the Entomostraca with Rotifera might be sufficient to show, what Burmeister, Dana, and Leydig have proved in another way, that Rotifera are genuine Crustacea, and not Worms. The vegetable character of most of the Anentera has been satisfactorily illustrated. I have not yet been able to arrive at a definite result respecting the Rhizopods, though they may represent, in the type of Mollusks, the stage of yolk segmentation of Gasteropods. From these remarks it should be inferred, that I do not consider the Protozoa as a distinct branch of the animal kingdom, nor the Infusoria as a natural class.[2]

Taking the class of Worms, in the widest sense, it would thus embrace the

[1] That Vorticellidæ are Bryozoa, has already been stated above.

[2] SCHULTZE, (M.,) Beiträge zur Naturgeschichte den Turbellarien, Greifswald, 1851, 4to., fig. — Zoologische Skizzen, Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 178. — MÜLLER, (J.,) Ueber eine eigenthümliche Wurmlarve, etc., Archiv, 1850, p. 485. — DESOR, (E.,) On the Embryology of Nemertes, with an Appendix on the Embryonic Development of Polynoe, Boston Journ. Nat. Hist. 1850, vol. 6, p. 1; Müller's Archiv, 1848, p. 511. — AGASSIZ, (L.,) Colpoda and Paramecium are larvæ of Planariæ, Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 439. — GIRARD, (CH.,) Embryonic Development of Planocera elliptica, Jour. Ac. Nat. Sc. Phil., 2d ser. 1854, vol. 2, p. 307. — EHRENBERG, (C. G.,) Die Infusionsthierchen, etc., q. a. — KÜTZING, (F. T.,) Ueber die Verwandlung der Infusorien in niedere Algenformen, Nordhausen, 1844, 4to. fig. — SIEBOLD, (C. TH. E. v.,) Ueber einzellige Pflanzen und Thiere, Zeitsch. f. wiss. Zool. 1849, vol. 1, p. 270. — NAEGELI, (C.,) Gattungen einzelliger Algen, Zurich, 1849, 4to. fig. — BRAUN, (A.,) Algarum unicellularium genera nova et minus cognita, Leipzig, 1855, 4to. fig. — COHN, (F.,) Beiträge zur Entwickelungsgeschichte der Infusorien Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 257. — Beiträge zur Kenntniss der Infusorien, Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 420. — Ueber Encystirung von Amphileptus fasciola, ibid. p. 434. — SCHULTZE, (M.,) Ueber den Organismus der Polythalamien, Leipzig, 1854, 1 vol. fol. fig. — Beobachtungen über die Fortpflanzung der Polythalamien, Müller's Archiv, 1856, p. 165. — AUERBACH, (L.,) Ueber die Einzelligkeit der Amoeben Zeitsch. f. wiss. Zool. 1855, vol. 7, p. 365. — Ueber Encystirung von Oxytricha Pellionella, Zeitsch. f. wiss. Zool. 1854, vol. 5, p. 430. — CIENKOWSKY, Ueber Cystenbildung bei Infusorien, Zeitsch. f. wiss. Zool. 1855, vol. 6, p. 301.

Helminths, Turbellariæ, and Annulata. The embryology of these animals still requires careful study, notwithstanding the many extensive investigations to which they have been submitted; the intestinal Worms especially continue to baffle the zeal of naturalists, even now when the leading features of their development are ascertained. The Nematoids undergo a very simple development, without alternate generations, and as some are viviparous their changes can easily be traced.[1] The Cestods and Cystici, which were long considered as separate orders of Helminths, are now known to stand in direct genetic connection with one another, the Cystici being only earlier stages of development of the Cestods.[2] The Trematods exhibit the most complicated phenomena of alternate generations; but as no single species has thus far been traced through all the successive stages of its transformations, doubts are

[1] STEIN, (F.,) Beiträge zur Entwickelungsgeschichte der Eingeweidewürmer, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 196. — NELSON, (H.,) On the Reproduction of the Ascaris Mystax, Philos. Trans. R. Soc., 1852, II., p. 563. — GRUBE, (E.,) Ueber einige Anguillulen und die Entwickelung von Gordius aquaticus, Wiegmann's Archiv, 1849, I., p. 358. — SIEBOLD, (C. TH. E. v.,) Ueber die Wanderung der Gordiaceen, Uebers. d. Arb. und Ver. schles. Ges. f. vaterl. Kultur., 1850, p. 38. — MEISSNER, (G.,) Beiträge zur Anatomie und Physiologie von Mermis albicans, Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 207. — Beobachtungen über das Eindringen der Saamenelemente in den Dotter, Zeitsch. f. wiss. Zool., 1855, vol. 6, p. 208, und 272. — Beiträge zur Anatomie und Physiologie der Gordiaceen, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 1. — KÖLLIKER, (A.,) Beiträge zur Entwickelungsgeschichte wirbelloser Thiere, Müller's Archiv, 1843, p. 68. — BAGGE, (H.,) Dissertatio inaug. de evolutione Strongyli auricularis et Ascaridis acuminatæ, Erlangen, 1841, 4to. fig. — LEIDY, (JOS.,) A Flora and Fauna within living Animals, Smithson. Contrib. 1853, 4to. fig. — LUSCHKA, (H.,) Zur Naturgeschichte der Trichina spiralis, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 69. — BISCHOFF, (TH.,) Ueber Ei- und Samenbildung und Befruchtung bei Ascaris Mystax, Zeitsch. f. wiss. Zool., 1855, vol. 6, p. 377. — Widerlegung, des von DR. KEBER bei den Najaden und DR. NELSON bei den Ascariden behaupteten Eindringens der Spermatozoiden in das Ei, Giessen, 1854, 4to. fig. — Bestätigung des von DR. NEWPORT bei den Batrachiern und DR. BARRY bei den Kaninchen behaupteten Eindringens der Spermatozoiden in das Ei, Giessen, 1854, 4to.

[2] VAN BENEDEN, (P. J.,) Les Helminthes Cestoides, etc., Bullet. Ac. Belg., vol. 16, et seq.; Mém. Ac. Brux., 1850, vol. 17, et seq. — KÖLLIKER, (A.,) Beiträge, etc., q. a.; p. 81. — SIEBOLD, (C. TH. E. v.,) Ueber den Generationswechsel der Cestoden, etc., Zeitsch. wiss. Zool., 1850, vol. 2, p. 198. — Ueber die Umwandlung von Blasenwürmer in Bandwürmer, Uebers. d. Arb. und Ver. d. schles. Ges. f. vaterl. Kultur, 1852, p. 48. — Ueber die Verwandlung des Cysticercus pisiformis in Tænia serrata, Zeitsch. f. wiss. Zool., 1853, vol. 4, p. 400. — Ueber die Verwandlung der Echinococcus-Brut in Tænien, Ibid., 1853, p. 409. — Ueber die Band-und Blasenwürmer, nebst einer Einleitung über die Entstehung der Eingeweidewürmer, Leipzig, 1854, 8vo. fig. — HUXLEY, (TH. H.,) On the Anatomy and Development of Echinococcus veterinorum, Ann. and Mag. Nat. Hist. 2d ser., vol. 14, p. 379. — KÜCHENMEISTER, (FR.,) Ueber die Umwandlung der Finnen (Cysticerci) in Bandwürmer (Tæniæ) Prag. Vierteljahrssch, 1852, p. 106. — WAGENER, (R. G.,) Die Entwickelung der Cestoden, Bonn, 1855, 1 vol. 4to. fig. — MEISSNER, (G.,) Zur Entwickelungsgeschichte und Anatomie der Bandwürmer, Zeitsch. f. wiss. Zool., 1854, vol. 5, p. 380. — LEUCKART, (R.,) Erziehung des Cysticercus fasciolaris aus den Eiern der Tænia crassicollis, Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 139.

still entertained respecting the genetic connection of many of the forms which appear to belong to the same organic cycle.[1] It is also still questionable, whether Gregarinæ and Psorospermia are embryonic forms or not, though the most recent investigations render it probable that they are.[2] The development of the Annulata, as they are now circumscribed, exhibits great variety;[3] some resemble more the Nematods, in their metamorphoses, while others, the Leeches for instance,

[1] Nordmann, (Al. v.,) Micrographische Beiträge zur Naturgeschichte der wirbellosen Thiere, Berlin, 1832, 4to. fig. — Bojanus, (L.,) Zerkarien und ihr Fundort, Isis 1818, vol. 4, p. 729. — Enthelmintica Isis 1821, p. 162. — Carus, Beobachtungen über einen merkwürdigen Eingeweidewurm, Leucochloridium paradoxum, Nov. Act. Ac. Nat. Cur., vol. 17, p. 85. — Siebold, (C. Th. E. v.,) Helminthologische Beiträge, Wiegman's Archiv, 1835, vol. 1, p. 45. — Ueber die Conjugation des Diplozoon paradoxum, etc., Zeitsch. f. wiss., Zool., 1851, vol. 3, p. 62. — Gyrodactylus, ein ammendes Wesen. Zeitsch. f. wiss. Zool., 1849, vol. 1, p. 347. — Steenstrup, (J.,) Generationswechsel, etc., q. a. — Bilharz, (Th.,) Ein Beiträg zur Helminthographia humana, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 59. — Agassiz, (L.,) Zoölogical Notes, etc., Amer. Journ. Sc. and A. 1852, vol. 13, p. 425. — Baer, (K. E. v.,) Beiträge zur Kenntniss der niedern Thiere, Act. Nov. Nat. Cur. 1827, vol. 13. — Aubert, (H.,) Ueber das Wassergefässsystem, die Geschlechtsverhältnisse, die Eibildung und die Entwickelung von Aspidogaster conchicola, Zeitsch. f. wiss. Zool. 1855, vol. 6, p. 349. — Leidy, (Jos.,) Description of two new Species of Distoma, with the partial History of one of them, Jour. Ac. Nat. Sc. Phil. 1850, vol. 1, p. 301, fig.

[2] Müller, (J.,) Ueber eine eigenthümliche krankhafte parasitische Bildung, etc., Müller's Archiv, 1841, p. 477. — Ueber parasitische Bildungen etc., Müller's Archiv, 1842, p. 193. — Dufour, (L.,) Note sur la Grégarine, etc., Ann. Sc. Nat., 1828, vol. 13, p. 366, fig. — Ibid., 2de sér., 1837, vol. 7, p. 10. — Siebold, (C. Th. E. v.,) Beiträge etc., q. a.; p. 56–71. — Hammerschmidt, (C. Ed.,) Helminthologische Beiträge, Isis 1838, p. 351. — Kölliker, (A.,) Die Lehre von der thierischen Zelle, etc., Zeitsch. wiss. Botanik. 1845, vol. i., p. 46, and p. 97. — Beiträge zur Kenntniss niederer Thiere, Zeitsch. f. wiss. Zool. 1848, vol. i. p. 1. — Henle, (J.,) Ueber die Gattung Gregarina, Müller's Archiv, 1845, p. 369. — Frantzius, (Al. v.,) Observationes quædam de Gregarinis, Berolini, 1846. — Stein, (F.,) Ueber die Natur der Gregarinen, Müller's Archiv, 1848, p. 182, fig. — Bruch, (C.,) Einige Bemerkungen über die Gregarinen, Zeitsch. f. wiss. Zool. 1850, vol. 2, p. 110. — Leydig, (F.,) Ueber Prorospermien und Gregarinen, Müller's Archiv, 1851, p. 221. — Leidy, (Jos.,) On the Organization of the Genus Gregarina, Trans. Amer. Phil. Soc. 1851, vol. 10, p. 233. — Some Observations on Nematoidea imperfecta and Descriptions of three parasitic Infusoria, Trans. Amer. Phil. Soc. 1851, vol. 10, p. 241. — Lieberkühn, (N.,) Ueber die Psorospermien, Müller's Archiv, 1854, p. 1.

[3] Weber, (E. H.,) Ueber die Entwickelung von Hirudo medicinalis, Meckel's Archiv, 1828, p. 366, fig. — Filippi, (Fil. de,) Sopra l'anatomia e lo sviluppo delle Clepsine, Pavia, 1839, 8vo. fig. — Loven, (J.,) Beobachtungen über die Metamorphose einer Annelide, K. Vet. Ac. Handl. 1840, Wiegmann's Archiv, 1842, vol. i., p. 302. — Oersted, (A. S.,) Ueber die Entwickelung der Jungen bei einer Annelide, etc., Wiegmann's Archiv, 1845, vol. i., p. 20. — Sars, (M.,) Zur Entwickelung der Anneliden, Wiegmann's Archiv, 1845, vol. i., p. 11. — Menge, (A.,) Zur Roth-Würmer Gattung Euaxes, Wiegmann's Archiv, 1845, vol. i., p. 24. — Grube, (A. E.,) Zur Anatomie und Entwickelung der Kiemenwürmer, Königsberg, 1838, 4to. — Actinien, Echinodermen und Würmer, etc., Königsberg, 1840, 4to. fig. — Untersuchungen über die Entwickelung der Clepsine, Dorpat, 1844. — Edwards, (H. Milne,) Observations sur le développement des Annélides, Ann. Sc. Nat. 3e sér. 1845, vol. 3, p. 145. — Koch, (H.,) Einige

approximate more the type of the Trematods. The Sipunculoids appear to be more closely related to the Annulata than to the Holothurioids.[1]

The class of Crustacea, on the contrary, may be considered as one of the best known, as far as its zoölogical characters and embryonic growth are concerned; the only point still questioned being the relationship of the Rotifera.[2] In their mode of development the Lernæans, the Entomostraca proper, and the Cirripeds agree as closely with one another as they differ from the higher Crustacea. This conformity[3] is the more interesting, as the low position the Entomostraca hold in the

Worte zur Entwickelungsgeschichte der Eunice, mit einem Nachworte von Kölliker, N. Denksch. Schw. Gesell., 1847, vol. 8, 4to. fig. — QUATREFAGES, (A. DE,) Mémoire sur l'Embryogénie des Annélides, Ann. Sc. Nat. 3e sér., 1848, vol. 10, p. 153, fig. — DESOR, (ED.,) On the Embryology, etc., q. a. — LEIDY, (JOS.,) Descriptions of some American Annelida abranchia, Journ. Ac. Nat. Sc. Phil. 1850, vol. 2, p. 43, fig., (Lumbricillus contained several thousand large Leucophrys. The case related here by Leidy seems to me to indicate rather the hatching of Opalinas from the eggs of Lumbricillus, than the presence of parasitic Leucophrys.) — SCHULTZE, (M.,) Ueber die Fortpflanzung durch Theilung bei Nais proboscidea, Wiegman's Archiv, 1849, I., p. 293; id. 1852, I., p. 3. — Zoologische Skizzen (Arenicola piscat.) Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 192. — BUSCH, (W.,) Beob. über Anat. und Entw. q. a. (p. 55.) — MÜLLER, (M.,) Observationes anatomicæ de Vermibus quibusdam maritimis, Berolini, 1852, 4to.; Müller's Archiv, 1852, p. 323. — Ueber die weitere Entwickelung von Mesotrocha sexoculata, Müller's Archiv, 1855, p. 1. — Ueber Sacconereis helgolandica, Müller's Archiv, 1855, p. 13. — KROHN, (A.,) Ueber die Ercheinungen bei der Fortpflanzung von Syllis, Wiegman's Archiv, 1852, I., p. 66. — Ueber die Sprösslinge von Autolytus prolifer Gr., Müller's Archiv, 1855, p. 489. — LEUCKART, (R.,) Ueber die ungeschlechtliche Vermehrung bei Nais proboscidea, Wiegman's Archiv, 1851, p. 134. — Ueber die Jugendzustände einiger Anneliden, Wiegman's Archiv, 1855, I., p. 63.

[1] PETERS, (W.) Ueber die Fortpflanzungsorgane des Sipunculus, Müller's Archiv, 1850, p. 382. — MÜLLER, (M.,) Ueber eine den Sipunculiden verwandte Wurmlarve, Müller's Archiv, 1850, p. 439. — KROHN, (A.,) Ueber die Larve des Sipunculus nudus, etc., Müller's Archiv, 1851, p. 368. — SCHMARDA, (L.,) Zur Naturgeschichte der Adria (Bonellia viridis) Denksch. Wien. Akad. 1852, vol. 4, p. 117, fig. — GEGENBAUER, (C.,) Ueber die Entwickelung von Doliolum, der Scheibenquallen und von Sagitta, Zeitsch. f. wiss. Zool. vol. 5, p. 13.

[2] EHRENBERG, (C. J.,) Die Infusionsthierchen, etc., q. a. — DALRYMPLE, (J..) Description of an Infusory Animalcule allied to the Genus Notommata. Philos. Trans. 1844, II., p. 331. — NAEGELI, (H.,) Beiträge zur Entwickelungsgeschichte der Räderthiere, inaug. Diss., Zurich, 1852, 8vo. fig. — LEYDIG, (FR.,) Ueber den Bau und die systematische Stellung der Räderthiere, Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 1. — Zur Anatomie und Entwickelungsgeschichte der Lacinularia socialis, Zeitsch. f. wiss. Zool. 1852, vol. 3, p. 452. — COHN, (F.,) Ueber die Fortpflanzung der Räderthiere, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 431. — HUXLEY, (TH. H.,) Lacinularia socialis, Trans. M. Soc., Micr. Journ. 1852, p. 12. — WILLIAMSON, (W. C.,) On the Anatomy of Melicerta ringens. Quart. Micr. Journ. 1852, p. 1.

[3] JURINE, (L.,) Histoire des Monocles qui se trouvent aux environs de Genève, Paris, 1806, 4to. fig. — EDWARDS, (H. MILNE,) in Cuvier, Règn. An. édit. illustr. q. a. Crustacés; represents young Limulus. — ZADDACH, (E. G.,) De Apodis cancriformis Anatome et Historia evolutionis Bonnæ, 1841, 4to. fig. — NORDMANN, (AL. v.,) Microgr. Beitr. q. a. — LEYDIG, (FR.,) Ueber Argulus foliaceus, ein Beitrag zur Anatomie, Histologie und Entwickelungsgeschichte dieses Thieres, Zeitsch. f. wiss. Zool. 1850, vol. 2, p. 323. — Ueber Artemia salina und Branchi-

class of Crustacea, agrees strikingly with their early appearance in geological times, while the form of the adult Cirripeds[1] and that of the Lernæans would hardly lead one to suspect their near relationship, which has, indeed, been quite overlooked until Embryology showed that their true position is among Crustacea. In the development of the higher Crustacea,[2] their superior rank is plainly exhibited, and few types show more directly a resemblance, in their early stages of development, to the lower members of their class, than the Brachyura.

In the class of Insects, I include Myriapods, Arachnoids, and the true Insects, as, according to the views expressed hereafter, these natural groups constitute only different degrees of complication of the same combination of organic systems, and must, therefore, be considered as natural orders of one and the same class. This class, though very extensively studied in a zoölogical and anatomical point of view, and as far as the habits of its representatives are concerned, still requires, however, much patient work, as the early embryonic development of these animals has been much less studied than their later transformations.[3] The type of the Arachnoids

pus stagnalis, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 280. — VANBENEDEN, (P. J.,) Recherches sur quelques Crustacés inférieurs Ann. Sc. Nat. 3e sér. 1851, vol. 16, p. 71. — Mémoire sur le développement et l'organisation des Nicothoés, Ann. Sc. Nat. 3e sér. 1850, vol. 13, p. 354. — BARRANDE, (J.,) Syst. sil. q. a.; contains the first observations upon the transformations of Trilobites.

[1] THOMPSON, (W. V.,) Zoölogical Researches and Illustrations, or Natural History of nondescript or imperfectly known Animals, Cork, 1828–34, 8vo., fig. — BURMEISTER, (H.,) Beiträge zur Naturgeschichte der Rankenfüsser, (Cirripedia,) Berlin, 1834, 1 vol. 4to. fig.—GOODSIR, (H. D. S.,) On the Sexes, Organs of Reproduction, and Development of Cirripeds, Ed. N. Phil. J. 1843, No. 35, p. 88, fig. — MARTIN ST. ANGE, (G. J.,) Mémoire sur l'organisation des Cirripèdes et sur leurs rapports naturels avec les animaux articulés, Ann. Sc. Nat. 1831, p. 366, fig. — DARWIN, (CH.,) A Monograph of the sub-class Cirripedia, with Figures of all the Species, London, 1851, 2 vols. 8vo. (Ray Society.) — BATE, (SPENCE,) On the Development of the Cirripedia, Ann. and Mag. Nat. Hist. 2d ser. vol. 8, p. 324.

[2] RATHKE, (H.,) Untersuchungen über die Bildung und Entwickelung des Flusskrebses, Leipzig, 1829, 1 vol. fol. fig. — Beiträge zur Fauna Norvegica, Act. Nov. Ac. Leop. Cæs. vol. 20. — Beiträge zur vergleichenden Anatomie und Physiologie, Reisebemerkungen aus Skandinavien, Dantzig, 1842, 4to. — Zur Morphologie, Reisebemerkungen aus Taurien, Riga und Leipzig, 1837, 4to. fig. — Ueber die Entwickelung der Decapoden, Müller's Archiv, 1836, p. 187, Wiegman's Archiv, 1840, I., p. 241. — Beobachtungen und Betrachtungen über die Entwickelung der Mysis vulgaris, Wiegman's Archiv, 1839, p. 195, fig. — ERDL, (M. P.,) Entwickelung des Hummereies, München, 1843, 4to. fig. — EDWARDS, (H. MILNE,) sur la génération des Crustacés, Ann. Sc. Nat. 1829. — Observations sur les changements de forme que divers Crustacés éprouvent dans le jeune âge, Ann. Sc. Nat. 2de sér. vol. 3, p. 321. — AGASSIZ, (L.,) Zoölogical Notes, etc., Am. Jour. Sc. and A., 1852, p. 426. — Recent Researches, etc., Am. Journ. Sc. and A., 1852, vol. 16, p. 136.

[3] HEROLD, (M.,) Entwickelungsgeschichte der Schmetterlinge, etc., Kassel und Marburg, 1815, 4to. fig. — Disquisitiones de animalium vertebris carentium in ovo formatione, Frankfurt a. M., 1835, fol. fig. — RATHKE, (H.,) Entwickelungsgeschichte der Blatta germanica, Meckel's Archiv, 1832. — Zur Entwickelungsgeschichte der Maulwurfsgrille (Gryl-

embraces two groups, the Acari and the Arachnoids proper, corresponding respectively in this class to the Entomostraca and the higher Crustacea. The embryo of the Acari resembles somewhat that of the Entomostraca, whilst that of the true Spiders[1] recalls the metamorphosis of the higher Crustacea. On the ground of the similarity of their young, some animals, formerly referred to the class of Worms,[2] are now considered as Arachnoids; but the limits between the aquatic Mites and the Pycnogonums are not yet quite defined.

In the branch of Vertebrata, all classes have been extensively studied, and as far as the principal types are concerned, the leading features of their development are satisfactorily known. Much, however, remains to be done to ascertain the minor modifications characteristic of the different families. It may even be, that further investigations will greatly modify the general classification of the whole branch. The class of Fishes[3] may require subdivision, since the development of the Plagios-

lotalpa vulgaris,) Müller's Archiv, 1844, p. 27. — KÖLLIKER, (A.,) Observationes de prima Insectorum Genesi, Turici, 1842, 4to. fig. — ZADDACH, (G.,) Die Entwickelung des Phryganiden Eies, Berlin, 1 vol. 4to. 1854. — LEUCKARDT, (R.,) Ueber die Micropyle und den feinern Bau der Schalenhaut bei den Insekteneiern, Müller's Arch., 1855, p. 90. — NEWPORT, (GEO.,) On the Organs of Reproduction and the Development of Myriapoda, Phil. Trans. R. Soc., 1842, II. p. 99. — STEIN, (FR.,) Vergeichende Anatomie und Physiologie der Insecten, 1ste Monogr., Die weiblichen Geschlechtsorgane der Käfer, Berlin, 1847, fol. fig. — SIEBOLD, (C. TH. E. v.,) Ueber die Fortpflanzung von Psyche, Zeitsch. f. wiss. Zool., 1848, vol. 1, p. 93. — LEYDIG, (FR.,) Einige Remerkungen über die Entwickelung der Blattläuse, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 62. — MEYER, (H.,) Ueber die Entwickelung des Fettkörpers, der Tracheen und der keimbereitenden Geschechtstheile bei den Lepidopteren, Zeitsch. f. wiss. Zool., 1849, vol. 1. — BURNETT, (W. J.,) Researches on the Development of viviparous Aphides, Amer. Journ. Sci. and Arts, 1854, vol. 17, p. 62 and 261. — As far as the metamorphoses of Insects, after the eclosion of the larva, are concerned, I must refer to the works of Reaumer and Roesel already quoted, and to almost every modern book upon Entomology. The metamorphoses of North American Insects are minutely described in Harris's Report, q. a.

[1] HEROLD, (M.,) De generatione Aranearum in ovo, Marburgi, 1824, fol. fig. — RATHKE, (H.,) Ueber die Entwickelung des Scorpions; Zur Morphologie, q. a. — VANBENEDEN, (P. J.,) Recherches sur l'Histoire naturelle et le développement de l'Atax ypsilophora, Mém. Ac. Brux., 1850, vol. 24, p. 444. — WITTICH, (W. H. v.,) Observationes quædam de aranearum ex ovo evolutione, Diss. inaug. Halis Sax., 1845. — Die Entstehung des Arachnideneies im Eierstock, Müller's Arch., 1849, p. 113. — CARUS, (J. V.,) Ueber die Entwickelung des Spinneneies, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 97. — DUJARDIN, (F.,) Mémoire sur des Acariens sans bouches, dont on a fait le genere Hypopus et qui sont le premier âge des Gamaoses, Ann. Sc. Nat., 1849, vol. 12, p. 243 et 259.

[2] KAUFMANN, (JOS.,) Ueber die Entwickelung und zoologische Stellung der Tardigraden, Zeitsch. f. wiss. Zool. 1851, vol. 3, p. 220. — VANBENEDEN, (P. J.,) Recherches sur l'organisation et le développement des Linguatules (Pentastoma,) Mém. Ac. Brux. vol. 15, I., p. 188. — SCHUBERT, (T. D.,) Ueber Entwickelung von Pentastomum tænioides Zeitsch. f. wiss. Zool. 1852, vol. 4, p. 117. — WILSON, (E.,) Researches into the Structure and Development of a newly discovered Parasitic Animalcule of the Human Skin, Phil. Trans. R. Soc. 1844, p. 305.

[3] FORCHHAMMER, (G.,) De Blennii vivipari

toms differs greatly from that of the ordinary fishes. As it now stands in our systems, the class of Fishes is certainly the most heterogeneous among Vertebrata.

formatione et evolutione observationes, Kiel, 1819, 4to. — PREVOST, (J. L.,) De la génération chez le Séchot (Cottus Gobio), Mém. Soc. Phys. et Hist. Nat., Genève, vol. 4, 1828, 4to. — RATHKE, (H.,) Beiträge zur Geschichte der Thierwelt, Halle, 1820–27, 4 vols. 4to. fig. — Abhandlungen zur Bildungs- und Entwickelungsgeschichte des Menschen und der Thiere. Leipzig, 1832-33, 2 vols. 4to. fig. — Ueber das Ei einiger Lachsarten, Meckel's Archiv, 1832, p. 392.— BAER, (K. E. v.,) Untersuchungen über die Entwickelungsgeschichte der Fische, Leipzig, 1835, 4to. — Also Entw. der Thiere, q. a., vol. 2d. — DAVY, (J.,) On the Development of the Torpedo, Philos. Trans. R. Soc., 1834. — FILIPPI, (FIL. DE,) Memoria sullo sviluppo del Gobius fluviatilis, Anna. Medic., Milano, 1841, 8vo. fig. — RUSCONI, (M.,) Sopra la fecondatione artificiale nei pesci, Giorn. delle Sc. Med.-chir., Pavia, vol. 9; tranls. in Müller's Archiv, 1840, p. 185. — Lettre sur les changements que les œufs de Poissons éprouvent avant qu'ils aient pris la forme d'embryon, Ann. Sc. Nat., 2de sér. vol. 5; transl. Mag. Zool. and Bot., I., p. 586. — AGASSIZ, (L.,) Histoire naturelle des Poissons d'eau douce de l'Europe centrale, vol. 1. Embryologie des Salmones, par C. VOGT, Neuchâtel, 1842, 8vo. atlas fol. These investigations were made under my direction and supervision. — MÜLLER, (J.,) Ueber den glatten Hai des Aristoteles, und über die Verschiedenheiten unter den Haifishen und Rochen in der Entwickelung des Eies, Berlin, 1842, fol. fig. — LEUCKART, (F. S.,) Untersuchungen über die äussern Kiemen der Embryonen von Rochen und Haien, Stuttgardt, 1836, 8vo. fig. — LEYDIG, (FR.,) Beiträge zur microscopischen Anatomie und Entwickelungsgeschichte der Rochen und Haie, Leipzig, 1852, 1 vol. 8vo. fig. — CARUS, (C. G.,) Erläuterungstafeln, etc., No. 3, Leipzig, 1831, fol. fig. — SHAW, (J.,) Account of some Experiments and Observations on the Parr, etc., Edinb. New Phil. Journ., vol. 21, p. 99. — On the Development and Growth of the Fry of the Salmon, etc., Ibid. vol. 24, p. 165; also Ann. Nat. Hist., I. p. 75, and IV. p. 352. — YARRELL, (W.,) Growth of the Salmon in Fresh Water, Ann. and Mag. Nat. Hist., IV. p. 334. — DUVERNOY, (G. L.,) Observations pour servir à la connaissance du développement de la Pécilie de Surinam, An. Sc. Nat., 1844, 3e sér. I. p. 313, fig. — COSTE, (P.,) Histoire générale et particulière du développement des corps organisés, Paris, 1847–53, 4to., Atl. fol., 2d Fasc., Epinoche. — QUATREFAGES, (ARM. DE,) Mémoire sur les Embryons des Syngnathes, Ann. Sc. Nat., 2de sér. vol. 18, p. 193, fig. — Sur le développement embryonaire des Blennies, etc., Comptes-Rendus, vol. 17, p. 320. — VALENCIENNES, (A.,) Anableps in CUVIER et VALENCIENNES, Histoire naturelle des Poissons, Paris, 1846, vol. 18, p. 245. — WYMAN, (J.,) Observations on the Development of Anableps Gronovii, Journ. Bost. Nat. Hist., 1854, vol. 6, fig. — AGASSIZ, (L.,) Extraordinary Fishes from California, constituting a new family, Amer. Journ. Sc. and A., 1853, vol. 16, p. 380. — Embryology of Lophius americanus, Proc. Am. Ac. 1855. — LEREBOULLET, (A.,) Recherches sur l'Anatomie des organes génitaux des animaux Vertébrés, N. Act. Ac. Nat. Cur., vol. 23, p. 1. — Ann. Sc. Nat., 4e sér. vol. 1. — AUBERT, (H.,) Beiträge zur Entwickelungsgeschichte der Fische, Zeitsch. f. wiss. Zool., 1853, vol. 5, p. 94; 1855, vol. 7. — VALENTIN, (G.,) Zur Entwickelungsgeschichte der Fische, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 267. — LEUCKART, (R.,) Ueber die allmählige Bildung der Körpergestalt bei den Rochen, Zeitsch. f. wiss. Zool., 1850, vol. 2, p. 258. — HAECKEL, (E.,) Ueber die Eier der Scomberesoces, Müller's Arch., 1855, p. 23. — RETZIUS, (A.,) Ueber den grossen Fetttropfen in den Eiern der Fische, Müller's Arch., 1855, p. 34. — BRUCH, (C.,) Ueber die Micropyle der Fische, Zeitsch. f. wiss. Zool., 1855, vol. 7, p. 172. — REICHERT, (K. B.,) Ueber die Micropyle der Fischeier, etc., Müller's Arch., 1856, p. 83. — DOWLER, (B.,) Discovery of a Viviparous Fish in Louisiana, Amer. Jour. Sc. and Arts, 1855, vol. 19, p. 133, with Remarks by L. AGASSIZ, p. 136.—SCHULTZE, (M.,) Note sur le développement des Pétromyzons, Comptes-Rendus, 1856, p. 336; Ann. and Mag. Nat. Hist., 2d ser.

The disagreement of authors as to the limits and respective value of its orders and families may be partly owing to the unnatural circumscription of the class itself.[1] As to the Reptiles, it is already certain, that the Amphibia and Reptiles proper, so long united as one class, constitute two distinct classes. In the main, the development of the true Reptiles[2] agrees very closely with that of the Birds, while the Amphibians[3] resemble more the true fishes. In no class are renewed embryological

1856, vol. 17, p. 443. — MÜLLER, (A.,) Ueber die Entwickelung der Neunaugen, Müller's Arch., 1856, p. 303. The unexpected facts mentioned here, render it highly probable, that Amphioxus is the immature state of some marine Cyclostom.

[1] The peculiarities of the development of the Plagiostoms consist not so much in the few large eggs they produce, and the more intimate connection which the embryo of some of them assumes with the parent, than in the development itself, which, notwithstanding the absence of an amnios and an allantois, resembles closely, in its early stages, that of the Reptiles proper and of the Birds, especially in the formation of the vascular system, the presence of a sinus terminalis, etc. Again, besides the more obvious anatomical differences existing between the Plagiostoms and the bony Fishes, it should be remembered that, as in the higher Vertebrata, the ovary is separated from the oviducts in the Sharks and Skates, and the eggs are taken up by a wide fallopian tube. That the Plagiostoms can hardly be considered simply as an order in the class of Fishes, could already be inferred from the fact, that they do not constitute a natural series with the other Fishes. I would, therefore, propose the name of SELACHIANS for a distinct class embracing the Sharks, Skates, and Chimæras. Recent investigations upon the Cyclostoms, show them also to differ widely from the Fishes proper, and they too ought to be separated as a distinct class, for which the name of MYZONTES may be most appropriate.

[2] VOLKMANN, (G. W.,) De Colubri Natricis Generatione, Lipsiæ, 1834, 4to. — RATHKE, (H.,) Entwickelungsgeschichte der Natter, (Coluber Natrix,) Königsberg, 1839, 4to. fig. — WEINLAND, (D.,) Ueber den Eizahn der Ringelnatter, Würt. Nat. Hist. Jahreshefte, 1855. — TIEDEMANN, (F.,) Ueber das Ei und den Fœtus der Schildkröte, Heidelberg, 1828, 4to. fig. — BAER, (K. E. v.,) Beiträge zur Entwickelungsgeschichte der Schildkröten, Müller's Archiv, 1834, p. 544. — RATHKE, (H.,) Ueber die Entwickelung der Schildkröten, Braunschweig, 1848, 4to. fig.

[3] RÖSEL v. ROSENHOF, (A. J.,) Historia naturalis Ranarum nostratium, etc., Norimb., 1758, fol. fig. — FUNK, (A. F.,) De Salamandræ terrestris vita, evolutione, formatione, etc., Berlin, 1826, fol. fig. — RATHKE, (H.,) Diss. de Salamandrarum corporibus adiposis eorumque evolutione, Berol, 1818. — Ueber die Entstehung und Entwickelung der Geschlechtstheile bei den Urodelen, N. Schr., Dantz. Naturf. Ges., 1820. — STEINHEIM, (L.,) Die Entwickelung der Frösche, Hamburg, 1820, 8vo. fig. — HASSELT, (J. CONR., VAN,) Dissert. exhibens Observationes de metamorphosi quarumdam partium Ranæ temporariæ, Göttingæ, 1820, 8vo. — PREVOST, (J. L.,) et LEBERT, Mémoire sur la formation des organes de la circulation et du Sang dans les Batraciens, Ann. Sc. Nat., 3e sér. I. p. 193, fig. — RUSCONI, (M.,) Développement de la Grenouille commune, depuis le moment de sa naissance jusqu' à son état parfait, Milan, 1828, 4to. fig. — Amours des Salamandres aquatiques et développement du Tétard de ces Salamandres, etc., Milan, 1822, 4to. fig. — BAER, (K. E. v.,) Die Metamorphose des Eies der Batrachier vor der Erscheinung des Embryo, etc., Müller's Archiv, 1834, p. 481. — Entwickelungsgeschichte, etc., vol. 2d, p. 280. — REICHERT, (K. B.,) Das Entwickelungsleben im Wirbelthierreich, Berlin, 1840, 4to. fig. — Vergleichende Entwickelungsgeschichte des Kopfes der nackten Amphibien, etc., Königsberg, 1838, 4to. fig. — Ueber den Furchungsprocess der Batrachier-Eier, Müller's Archiv, 1841, p. 523. — VOGT, (C.,) Untersuchungen über die Entwickelungsgeschichte der Geburtshelfer-

investigations, extending over a variety of families, so much needed, as in that of Birds, though the general development of these animals is, perhaps, better known than that of any other type;[1] while the class of Mammalia[2] has found in Bischoff a most successful and thorough investigator.[3]

kröte, Solothurn, 1841, 4to. fig. — Quelques observations sur l'embryologie des Batraciens, Ann. Sc. n., 3e sér. vol. 2, p. 45. — REMAK, (R.,) Untersuchungen über die Entwickelung der Wirbelthiere, Berlin, 1855, fol. — NEWPORT, (G.,) On the Impregnation of the Ovum in the Amphibia, Philos. Trans. R. Soc., 1851, I., p. 169. — WITTICH, (W. H. v.,) Beiträge zur morphologischen und histologischen Entwickelung der Harn- und Geschlechtswerkzeuge der nackten Amphibien, Zeitsch. f. wiss. Zool., 1852, vol. 4, p. 125. — WEINLAND, (D.,) Ueber den Beutelfrosch, Müller's Archiv, 1854, p. 449. — WYMAN, (J.,) Observations on Pipa americana, Am. Jour. Sc. and Arts, 2d ser. 1854, vol. 17, p. 369.

[1] PANDER, (CHR. H.,) Diss. sistens historiam metamorphoseos quam ovum incubatum prioribus quinque diebus subit, Wirceb. 1817, 8vo. — Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie, Würzb. 1817, fol. fig. — BAER, (K. E. v.,) Entwickelungsgeschichte, etc., vol. 1. — DUTROCHET, (H.,) Histoire de l'œuf des Oiseaux avant la ponte, Bull. Soc. Philom., 1819, p. 38. — HUNTER, (JOHN,) Observations on Animal Development, edited and his Illustrations of that process in the Bird described by R. OWEN, London, 1841, fol. fig. — PREVOST, (J. L.,) Mémoire sur le développement du poulet dans l'œuf, Ann. Sc. Nat., 1827, vol. 12, p. 415. — PREVOST, (J. L.,) et LEBERT, Mémoires sur la formation des organes de la circulation et du sang dans l'embryon du Poulet, Ann. Sc. Nat. 3e sér. I. p. 265; II. p. 222, fig.; III. p. 96. — BAUDRIMONT, (A.,) et MARTIN ST. ANGE, (G. J.) Recherches anatomiques et physiologiques sur le développement du fœtus, Paris, 1850, 4to. — MECKEL v. HEMSBACH, (H.,) Die Bildung der für partielle Furchung bestimmten Eier der Vögel, etc., Zeitsch. f. wiss. Zool., 1852, vol. 3, p. 420. — In no class are embryological investigations extending over a variety of families more needed than in that of Birds, if we should ever derive any assistance from the knowledge of their development for their natural classification.

[2] For the papers relating to the fœtal envelopes and the placenta and also to the different systems of organs or any organ in particular and for human embryology generally, see Bischoff's article "Entwickelungsgeschichte," in R. Wagner's Handwörterbuch der Physiologie, p. 867, where every thing that has been done in this direction, up to the year 1843, is enumerated. For more recent researches upon these topics consult, also, MÜLLER'S Archiv, WIEGMAN'S Archiv, SIEBOLD und KÖLLIKER'S Zeitsch. f. wiss. Zool., MILNE-EDWARDS, Ann. Sc. Nat., and the Annals and Magazine of Nat. Hist., etc.

[3] BISCHOFF, (TH. L. W.,) Entwickelungsgeschichte des Kaninchen-Eies, Braunschweig, 1842, 4to. fig. — Entwickelungsgeschichte des Hunde-Eies, Braunschweig, 1845, 4to. fig. — Entwickelungsgeschichte des Meerschweinchens, Giessen, 1852, 4to. fig. —Entwickelungsgeschichte des Rehes, Giessen, 1854, 4to. fig. — PREVOST, (J. L.,) et DUMAS, (J. A.,) De la génération chez les Mammifères, etc., Ann. Sc. Nat. 1824, vol. 3, p. 113, fig. — BOJANUS, (L.,) Observatio anatomica de fœtu canino 24 dierum, etc., Act. Ac. Nat. Cuv., vol. 10, p. 139, fig. — COSTE, (P.,) Embryogénie comparée, Paris, 1837, 8vo. Atlas 4to. — Histoire particulière et générale du développement des corps organisés, q. a. — Recherches sur le génération des Mammifères et le développement de la brebis, Ann. Sc. Nat., 1835, III. p. 78. — Recherches sur la génération des Mammifères, Paris, 1834, 4to. fig. — BERNHARDT, (C. A.,) Symbolæ ad Ovi Mammalium historiam ante pregnationem, Vratisl., 4to., Müller's Arch., 1835, p. 228. — BARRY, (M.,) Researches in Embryology, Phil. Trans. R. Soc. 1838, p. 301; 1839, p. 307; 1840, p. 529; 1841, p. 195. — BAER, (H. E. v.,) q. a. — OWEN, (R.,) On the Ova of the Ornithorhynchus paradoxus, Phil. Trans. 1834, p. 555. — On the Young of the Ornithorhynchus para-

Embryology has, however, a wider scope than to trace the growth of individual animals, the gradual building up of their body, the formation of their organs, and all the changes they undergo in their structure and in their form; it ought also to embrace a comparison of these forms and the successive steps of these changes between all the types of the animal kingdom, in order to furnish definite standards of their relative standing, of their affinities, of the correspondence of their organs in all their parts. Embryologists have thus far considered too exclusively, the gradual transformation of the egg into a perfect animal; there remains still a wide field of investigation to ascertain the different degrees of similarity between the successive forms an animal assumes until it has completed its growth, and the various forms of different kinds of full-grown animals of the same type; between the different stages of complication of their structure in general, and the perfect structure of their kindred; between the successive steps in the formation of all their parts and the various degrees of perfection of the parts of other groups; between the normal course of the whole development of one type compared with that of other types, as well as between the ultimate histological differences which all exhibit within certain limits. Though important fragments have been contributed upon these different points, I know how much remains to be done, from the little I have as yet been able to gather myself, by systematic research in this direction.

I have satisfied myself long ago, that Embryology furnishes the most trustworthy standard to determine the relative rank among animals. A careful comparison of the successive stages of development of the higher Batrachians furnishes, perhaps, the most striking example of the importance of such investigations. The earlier stages of the Tadpole exemplify the structure and form of those Ichthyoids which have either no legs, or very imperfect legs, with and without external gills; next it assumes a shape reminding us more of the Tritons and Salamanders, and ends with the structure of the Frog or Toad.[1] A comparison between the two latter families might prove further, that the Toads are higher than the Frogs, not only on account of their more terrestrial habits (see Sect. 16), but because the embryonic web, which, to some extent, still unites the fingers in the Frogs, disappears entirely in the Toads, and may be also, because glands are developed in their skin, which do not exist in Frogs. A similar comparison of the successive changes of a new species of Comatula discovered by Prof. Holmes, in the harbor of Charleston, in South Carolina, has shown me in what relation the different types of Crinoids of past ages stand to

doxus, Trans. Zool. Soc., i. p. 221; Proc. Zoöl. Soc., ii. p. 43; Ann. Sc. Nat., 2d ser. ii. p. 303; iii. p. 299. — On the Generation of the Marsupial Animals, etc., Phil. Trans., 1824, p. 333. — MEIGS, (CH.,) Observations on the Reproductive Organs and on the Fœtus of Delphinus Nesarnak, Journ. Ac. Nat. Sc. Phil., new ser. 1849, vol. 1, p. 267.

[1] AGASSIZ, (L.,) Twelve Lectures, etc., page 8.

these changes, and has furnished a standard to determine their relative rank; as it cannot be doubted, that the earlier stages of growth of an animal exhibit a condition of relative inferiority, when contrasted with what it grows to be, after it has completed its development, and before it enters upon those phases of its existence which constitute old age, and certain curious retrograde metamorphoses observed among parasites.

In the young Comatula there exists a stem, by which the little animal is attached, either to sea weeds, or to the cirrhi of the parent; the stem is at first simple and without cirrhi, supporting a globular head, upon which the so-called arms are next developed and gradually completed by the appearance of branches; a few cirrhi are, at the same time, developed upon the stem, which increase in number until they form a wreath between the arms and the stem. At last, the crown having assumed all the characters of a diminutive Comatula, drops off, freeing itself from the stem, and the Comatula moves freely as an independent animal.[1]

The classes of Crustacea and of Insects,[2] are particularly instructive in this respect. Rathke, however, has described the transformations of so many Crustacea, that I cannot do better than to refer to his various papers upon this subject,[3] for details relating to the changes these animals undergo during their earlier stages of growth. I would only add, that while the embryo of the highest Crustacea, the Brachyura, resembles by its form and structure the lowest types of this class, as the Entomostraca and Isopoda, it next assumes the shape of those of a higher order, the Macroura, before it appears with all the characteristics of the Brachyura.

Embryology furnishes, also, the best measure of the true affinities existing between animals. I do not mean to say, that the affinities of animals can only be ascertained by embryonic investigations; the history of Zoölogy shows, on the contrary, that even before the study of the formation and growth of animals had become a distinct branch of physiology, the general relationship of most animals had already been determined, with a remarkable degree of accuracy, by anatomical investigations. It is, nevertheless, true, that in some remarkable instances, the knowledge of the embryonic changes of certain animals gave the first clue to their true affinities, while, in other cases, it has furnished a very welcome confirmation of relationships, which, before, could appear probable, but were still very problematical. Even Cuvier considered, for instance, the Barnacles as a distinct class, which he placed

[1] A condensed account of the transformations of the European Comatula, may be found in E. FORBES's History of the British Starfishes, p. 10. The embryology of our species will be illustrated in one of my next volumes.

[2] See AGASSIZ's Twelve Lectures, p. 62, and Classification of Insects, etc., q. a. It is expected that Embryology may furnish the means of ascertaining the relative standing of every family.

[3] See above, page 79, note 2.

among Mollusks, under the name of Cirripeds. It was not until Thompson[1] had shown, what was soon confirmed by Burmeister and Martin St. Ange, that the young Barnacle has a structure and form identical with that of some of the most common Entomostraca, that their true position in the system of animals could be determined; when they had to be removed to the class of Crustacea, among Articulata. The same was the case with the Lernæans, which Cuvier arranged with the Intestinal Worms, and which Nordmann has shown upon embryological evidence to belong also to the class of Crustacea.[2] Lamarck associated the Crinoids with Polypi, and though they were removed to the class of Echinoderms by Cuvier, before the metamorphoses of the Comatula were known,[3] the discovery of their pedunculated young furnished a direct proof that this was their true position.

Embryology affords further a test for homologies in contradistinction of analogies. It shows that true homologies are limited respectively within the natural boundaries of the great branches of the animal kingdom.

The distinction between homologies and analogies, upon which the English naturalists have first insisted,[4] has removed much doubt respecting the real affinities of animals which could hardly have been so distinctly appreciated before. It has taught us to distinguish between real affinity, based upon structural conformity, and similarity, based upon mere external resemblance in form and habits. But even after this distinction had been fairly established, it remained to determine within what limits homologies may be traced. The works of Oken, Spix, Geoffroy, and Carus,[5] show to what extravagant comparisons a preconceived idea of unity may lead. It was not until Baer had shown that the development of the four great branches of the animal kingdom is essentially different,[6] that it could even be suspected that organs performing identical functions may be different in their essential relations to one another, and not until Rathke[7] had demonstrated that the yolk is in open communication with the main cavity of the Articulata, on the dorsal side of the animal, and not on the ventral side, as in Vertebrata, that a solid basis was obtained for the natural limitation of true homologies. It now appears more and more distinctly, with every step of the progress Embryology is making, that the structure of animals is only homologous within the limits of the four great branches

[1] THOMPSON'S Zool. Researches, etc.; BURMEISTER'S Beiträge, etc.; MARTIN ST. ANGE, Mém. sur l'organisation, etc., quoted above, page 79, note 1.

[2] NORDMANN'S Micrographische Beyträge, q. a.

[3] THOMPSON and FORBES, q. a., page 79.

[4] SWAINSON'S Geography and Classification, etc. See above, Sect. V., p. 20.

[5] See, above, Sect. IV., notes 1 and 2.

[6] BAER'S Entwickelungsgeschichte, vol. 1, p. 160 and 224. The extent of Baer's information and the comprehensiveness of his views, nowhere appear so strikingly as in this part of his work.

[7] RATHKE'S Unters. über Bild., etc., see, above, p. 79, note 2.

of the animal kingdom, and that general homology strictly proved, proves also typical identity, as special homology proves class identity.

The results of all embryonic investigations of modern times go to show more and more extensively, that animals are entirely independent of external causes in their development. The identity of the metamorphoses of oviparous and viviparous animals belonging to the same type, furnishes the most convincing evidence to that effect.[1] Formerly it was supposed that the embryo could be affected directly by external influences to such an extent, that monstrosities, for instance, were ascribed to the influence of external causes. Direct observation has shown, that they are founded upon peculiarities of the normal course of their development.[2] The snug berth in which the young undergo their first transformation in the womb of their mother in all Mammalia, excludes so completely the immediate influence of any external agent, that it is only necessary to allude to it, to show how independent their growth must be of the circumstances in which even the mother may be placed. This is equally true of all other viviparous animals, as certain snakes, certain sharks, and the viviparous fishes. Again, the uniformity of temperature in the nests of birds, and the exclusion, to a certain degree, of influences which might otherwise reach them, in the various structures animals build for the protection of their young or of their eggs,[3] show distinctly, that the instinct of all animals leads them to remove their progeny from the influence of physical agencies, or to make these agents subservient to their purposes, as in the case of the ostrich. Reptiles and terrestrial Mollusks bury their eggs to subtract them from varying influences; fishes deposit them in localities where they are exposed to the least changes. Insects secure theirs

[1] This seems the most appropriate place to remark, that the distinction made between viviparous and oviparous animals is not only untenable as far as their first origin in the egg is concerned, but also unphysiological, if it is intended, by this designation, to convey the idea of any affinity or resemblance in their respective modes of development. Fishes show more distinctly than any other class, that animals, the development of which is identical, in all its leading features, may either be viviparous or oviparous; the difference here arising only from the connection in which the egg is developed, and not from the development itself. Again, viviparous and oviparous animals of different classes differ greatly in their development, even though they may agree in laying eggs or bringing forth living young. The essential feature upon which any important generalization may be based, is, of course, the mode of development of the germ. In this respect we find that Selachians, whether oviparous or viviparous, agree with one another; this is also the case with the bony fishes and the reptiles, whether they are respectively oviparous or viviparous; even the placentalian and non-placentalian Mammalia agree with one another in what is essential in their development. Too much importance has thus far been attached to the connections in which the germ is developed, to the exclusion of the leading features of the transformations of the germ itself.

[2] BISHOFF, (TH. L. W.,) in R. Wagner's Handwörterbuch der Physiologie, Article "Entwickelungsgeschichte," p. 885.

[3] BURDACH'S Physiologie, etc., q. a. vol. 2, 2d ed. Sect. 334–38. See, also, KIRBY and SPENCE'S Introduction, etc., q. a.

in various ways. Most marine animals living in extreme climates, lay their eggs in winter, when the variations of external influences are reduced to a minimum. Everywhere we find evidence that the phenomena of life, though manifested in the midst of all the most diversified physical influences, are rendered independent of them to the utmost degree, by a variety of contrivances prepared by the animals themselves, in self-protection, or for the protection of their progeny from any influence of physical agents not desired by them, or not subservient to their own ends.

SECTION XIX.

DURATION OF LIFE.

There is the most extraordinary inequality in the average duration of the life of different kinds of animals and plants. While some grow and reproduce themselves and die in a short summer, nay, in a day, others seem to defy the influence of time.[1]

Who has thus apportioned the life of all organized beings? To answer this question, let us first look at the facts of the case. In the first place, there is no conformity between the duration of life and either the size, or structure, or habitat of animals; next, the system, in which the changes occurring during any period are regulated, differs in almost every species, there being only a slight degree of uniformity between the representatives of different classes, within certain limits.

In most Fishes and the Reptiles proper, for instance, the growth is very gradual and uniform, and their development continues through life, so much so that their size is continually increasing with age.

In others, the Birds, for instance, the growth is rapid during the first period of their life, until they have acquired their full size, and then follows a period of equilibrium, which lasts for a longer or shorter period in different species.

In others still, which also acquire within certain limits a definite size, the Mammalia, for instance, the growth is slower in early life, and maturity is attained, as in man, at an age which forms a much longer part of the whole duration of life.

In Insects, the period of maturity is, on the contrary, generally the shortest, while the growth of the larva may be very slow, or, at least, that stage of development last for a much longer time than the life of the perfect Insects. There is no

[1] SCHÜBLER, (GUST.,) Beobachtungen über jährliche periodisch wiederkehrende Erscheinungen im Thier- und Pflanzenreich, Tübingen, 1831, 8vo.—QUETELET, (A.,) Phénomènes périodiques, Ac. Brux.

more striking example of this peculiar mode of growth than the seventeen years locust, so fully traced by Miss M. H. Morris.[1]

While all longlived animals continue, as a matter of course, their existence through a series of years, under the varying influence of successive seasons, there are many others which are periodical in their appearance; this is the case with most insects,[2] but perhaps in a still more striking manner with Medusæ.[3]

The most interesting point in this subject is yet the change of character which takes place in the different stages of growth of one and the same animal. Neither Vertebrata, nor Mollusks, nor even Radiata exhibit in this respect any thing so remarkable in the continuous changes which an individual animal may undergo, as the Insects, and among them those with so-called complete metamorphoses, in which the young (the larva) may be an active, wormlike, voracious, even carnivorous being, which in middle life (the chrysalis) becomes a mummylike, almost motionless maggot, incapable of taking food, ending life as a winged and active insect. Some of these larvæ may be aquatic and very voracious, when the perfect insect is aërial and takes no food at all.[4]

Is there any thing in this regulation of the duration of life in animals which recalls the agency of physical forces? Does not, on the contrary, the fact, that while some animals are periodical and bound to the seasons in their appearance, and others are independent of the course of the year, show distinctly their independence of all those influences which, under a common expression, are called physical causes? Is this not further illustrated in the most startling manner by the extraordinary changes, above alluded to, which one and the same animal may undergo during different periods of its life? Does this not prove directly the immediate intervention of a power capable of controlling all these external influences, as well as regulating the course of life of every being, and establishing it upon such an immutable foundation, within its cycle of changes, that the uninterrupted action of these agents shall not interfere with the regular order of their natural existence?

There is, however, still another conclusion to be drawn from these facts: they point distinctly at a discriminating knowledge of time and space, at an appreciation of the relative value of unequal amounts of time and an unequal repartition of small, unequal periods over longer periods, which can only be the attribute of a thinking being.

[1] HARRIS's Insects injurious to Vegetation, p. 184.

[2] HEROLD, (E.,) Teutscher Raupen-Kalender, Nordhausen, 1845.

[3] AGASSIZ's Acalephs of North America, p. 228.

[4] BURMEISTER's Handb. d. Entom. etc. — LACORDAIRE, Introd. à l'Entomologie, etc. — KIRBY and SPENCE, Introd. to Entomol., etc., q. a., give accounts of the habits of Insects during their metamorphosis.

SECTION XX.

ALTERNATE GENERATIONS.

While some animals go on developing gradually from the first formation of their germ to the natural end of their life, and bring forth generation after generation, a progeny which runs with never varying regularity through the same course, there are others which multiply in various ways, by division and by budding,[1] or by a strange succession of generations, differing one from the other, and not returning, by a direct course, to their typical cycle.

The facts which have led to the knowledge of the phenomena now generally known under the name of *alternate generation*, were first observed by Chamisso and Sars, and afterwards presented in a methodical connection by Steenstrup, in his famous pamphlet on that subject.[2] As a brief account of the facts may be found in almost every text-book of Physiology, I need not repeat them here, but only refer to the original investigations, in which all the details known upon this subject may be found.[3] These facts show, in the first place with regard to Hydroid Medusæ, that the individuals born from eggs, may be entirely different from those which produced the eggs, and end their life without ever undergoing themselves such changes as would transform them into individuals similar to their parents;[4] they show further,

[1] Much information useful to the zoölogist, may be gathered from BRAUN's paper upon the Budding of Plants, q. a., p. 18, note 3. The process of multiplication by budding or by division, and that of sexual reproduction, are too often confounded by zoölogists, and this confusion has already led to serious misconstructions of well known facts.

[2] STEENSTRUP, (J.,) Ueber den Generationswechsel, q. a., p. 69, note 3.

[3] See the works quoted above, page 69, note 3, and p. 70, note 1, also CARUS, (V.,) Zur nähern Kenntniss des Generationswechsels, Leipzig, 1849, 8vo. — Einige Worte über Metamorphose und Generationswechsel, Zeitsch. f. wiss. Zool., 1851, vol. 3, p. 359. — OWEN, (R.,) On Parthenogenesis, or the Successive Production of Procreating Individuals from a single Ovum, London, 1849, 8vo. — On Metamorphosis and Metagenesis, Ann. and Mag. Nat. Hist., 2d ser. vol. 8, 1857, p. 59. — PROSCH, (V.,) Om Parthenogenesis og Generationsvexel et Bidrag til Generationslæren, Kiöbenhavn, 1851. — LEUCKART, (R.,) Ueber Metamorphose, ungeschlechtliche Vermehrung, Generationswechsel, Zeitsch. f. wiss. Zool,, vol. 3, 1851. — DANA, (J. D.,) On the Analogy between the Mode of Reproduction in Plants and the "Alternation of Generations" observed in some Radiata, Amer. Journ. A. and Sc., 2d ser. vol. 10, p. 341. — EHRENBERG, (C. G.,) Ueber die Formenbeständigkeit und den Entwickelungskreis der organischen Formen, Monatsber. der Akad., Berlin, 1852, 8vo.

[4] Polymorphism among individuals of the same species is not limited to Acalephs; it is also observed among genuine Polyps, the Madrepores, for example, and among Bryozoa, Ascidians, Worms, Crustacea (Lupea), and even among Insects (Bees).

that this brood originating from eggs, may increase and multiply by producing new individuals like themselves (Syncoryne), or of two kinds (Campanularia), or even individuals of various kinds, differing all to a remarkable extent, one from the other, (Hydractinia,) but in neither case resembling their common parent. None of these new individuals have distinct reproductive organs, any more than the first individuals born from eggs, their multiplication taking place chiefly by the process of budding; but as these buds remain generally connected with the first individual born from an egg, they form compound communities, similar to some polypstocks. Now some of these buds produce, at certain seasons, new buds of an entirely different kind, which generally drop off from the parent stock, at an early period of their development, (as in Syncoryna, Campanularia, etc.,) and then undergo a succession of changes, which end by their assuming the character of the previous egg-laying individuals, organs of reproduction of the two sexes developing meanwhile in them, which, when mature, lead to the production of new eggs; in others (as in Hydractinia,) the buds of this kind do not drop off, but fade away upon the parent stock, after having undergone all their transformations, and also produced in due time, a number of eggs.[1]

In the case of the Medusæ proper,[2] the parent lays eggs, from which originate polyplike individuals; but here these individuals divide by transverse constrictions into a number of disks, every one of which undergoes a succession of changes, which end in the production of as many individuals, each identical with the parent, and capable in its turn, of laying eggs, (some, however, being males and others females.) But the polyplike individuals born from eggs may also multiply by budding and each bud undergo the same changes as the first, the base of which does not die, but is also capable of growing up again and of repeating the same process.

In other classes other phenomena of a similar character have been observed, which bear a similar explanation. J. Müller[3] has most fully illustrated the alternate generations of the Echinoderms; Chamisso, Steenstrup, Eschricht, Krohn, and Sars, those of the Salpæ;[4] von Siebold, Steenstrup, and others, those of certain Intestinal Worms.[5]

This alternate generation differs essentially from metamorphosis, though some

[1] I have observed many other combinations of a similar character among the Hydroid Medusæ, which I shall describe at full length in my second volume; and to which I do not allude here, as they could not be understood without numerous drawings. The case of Hydractinia is not quite correctly represented in the works in which that animal has been described. Respecting Physalia and the other Siphonophora, see the works quoted above, p. 69, note 3.

[2] See SIEBOLD, and SARS, q. a., p. 69, note 3.

[3] MÜLLER, (J.,) Ueber den allgemeinen Plan, etc., q. a., p. 70, note 1.

[4] See the works, q. a., page 72, note 4.

[5] See the works, q. a., page 76, note 2, and 77, note 1.

writers have attempted to identify these two processes. In metamorphosis, as observed among Insects, the individual born from an egg goes on undergoing change after change, in direct and immediate succession, until it has reached its final transformation; but however different it may be at different periods of its life, it is always one and the same individual. In alternate generations, the individual born from an egg never assumes through a succession of transformations the character of its parent, but produces, either by internal or external budding or by division, a number, sometimes even a large number of new individuals, and it is this progeny of the individuals born from eggs, which grows to assume again the characters of the egg-laying individuals.

There is really an essential difference between the sexual reproduction of most animals, and the multiplication of individuals in other ways. In ordinary sexual reproduction, every new individual arises from an egg, and by a regular succession of changes assumes the character of its parents. Now, though all species of animals reproduce their kind by eggs, and though in each there is at least a certain number of individuals, if not all, which have sprung from eggs, this mode of reproduction is not the only one observed among animals. We have already seen how new individuals may originate from buds, which in their turn may produce sexual individuals; we have also seen how, by division, individuals may also produce other individuals differing from themselves quite as much as the sexual buds, alluded to above, may differ from the individuals which produce them. There are yet, still other combinations in the animal kingdom. In Polyps, for instance, every bud, whether it is freed from the parent stock or not, grows at once up to be a new sexual individual; while in many animals which multiply by division, every new individual thus produced assumes at once the characters of those born from eggs.[1] There is, finally, one mode of reproduction which is peculiar to certain Insects, in which several generations of fertile females follow one another, before males appear again.[2]

What comprehensive views the physical agents must be capable of taking, and what a power of combination they must possess, to be able to ingraft all these complicated modes of reproduction upon structures already so complicated! — But if we turn away from mere fancies and consider the wonderful phenomena just alluded to, in all their bearings, how instructive they appear with reference to this very question of the influence of physical agents upon organized beings! For here we have animals endowed with the power of multiplying in the most extraordinary ways, every species producing new individuals of its own kind, differing to the utmost from their parents. Does this not seem, at first, as if we had before us a perfect

[1] MILNE-EDWARDS, Rech. anat. et zool. faites pendant un Voyage sur les côtes de Sicile, 3 vols. 4to. fig.

[2] OWEN, Parthenogenesis, etc., q. a., p. 90.—BONNET, (CH.,) Traité d'Insectologie, etc., Paris, 1745.

exemplification of the manner in which different species of animals may originate, one from the other, and increase the number of types existing at first? And yet, with all this apparent freedom of transformation, what do the facts finally show? That all these transformations are the successive terms of a cycle, as definitely closed within precise limits, as in the case of animals, the progeny of which resembles for ever the immediate parent, in all successive generations. For here, as everywhere in the organic kingdoms, these variations are only the successive expressions of a well regulated cycle, ever returning to its own type.

SECTION XXI.

SUCCESSION OF ANIMALS AND PLANTS IN GEOLOGICAL TIMES.

Geologists hardly seem to appreciate fully, the whole extent of the intricate relations exhibited by the animals and plants whose remains are found in the different successive geological formations. I do not mean to say, that the investigations we possess respecting the zoölogical and botanical characters of these remains are not remarkable for the accuracy and for the ingenuity with which they have been traced. On the contrary, having myself thus far devoted the better part of my life to the investigation of fossil remains, I have learned early, from the difficulties inherent in the subject, better to appreciate the wonderful skill, the high intellectual powers, the vast erudition displayed in the investigations of Cuvier and his successors upon the faunæ and floræ of past ages.[1] But I cannot refrain

[1] CUVIER, (G.,) Recherches sur les Ossemens fossiles de Quadrupèdes, etc., Paris, 1812, 4 vols. 4to.; nouv. édit. Paris, 1821–23, 5 vols. 4to.; 4e édit. 10 vols. 8vo. and 2 vols. pl. 4to. — SOWERBY, (JAMES,) The Mineral Conchology of Great Britain, London, 1812–19, 6 vols. 8vo. fig. — SCHLOTTHEIM, (E. F. v.,) Die Petrefactenkunde, etc., Gotha, 1820, 8vo. fig. — LAMARCK, (J. B. DE,) Mémoires sur les fossiles des environs de Paris, Paris, 1823, 4to. fig. — GOLDFUSS, (G. A.,) Petrefacta Germaniæ, Düsseldorf, 1826–33, fol. fig. — STERNBERG, (KASPAR, M. GR. v.,) Versuch einer geognostisch-botanischen Darstellung der Flora der Vorwelt, Leipzig und Prag, 1820–38, fol. fig. — BRONGNIART, (AD.,) Prodrome d'une Histoire des Végétaux fossiles, Paris, 1818, 2 vols. 8vo. — Histoire des Végétaux fossiles, Paris, 1828–43, 2 vols. 4to. fig. — LINDLEY, (J.,) and HUTTON, (W.,) The Fossil Flora of Great Britain, London, 1831–37, 3 vols. 8vo. — GÖPPERT, (H. R.,) Systema Filicum fossilium, Vratisl. et Bonnæ, 1836, 4to. fig. — Die Gattungen der fossilen Pflanzen, verglichen mit denen der Jetztwelt, etc., Bonn, 1841–48, 4to. fig. — Monographie der fossilen Coniferen. Düsseldorf, 1850, 4to. fig. — More special works are quoted hereafter, but only such works shall be mentioned, which have led on, in the progress of Geology and Palæontology, or contain full reports of the present state of our science, and also such as have special reference to America. References to the description of species may be found in BRONN,

from expressing my wonder at the puerility of the discussions in which some geologists allow themselves still to indulge, in the face of such a vast amount of well digested facts as our science now possesses. They have hardly yet learned to see that there exists a definite order in the succession of these innumerable extinct beings; and of the relations of this gradation to the other great features exhibited by the animal kingdom, of the great fact, that the development of life is the prominent trait in the history of our globe,[1] they seem either to know nothing, or to look upon it only as a vague speculation, plausible perhaps, but hardly deserving the notice of sober science.

It is true, Palæontology as a science is very young; it has had to fight its course through the unrelenting opposition of ignorance and prejudice. What amount of labor and patience it has cost only to establish the fact, that fossils are really the remains of animals and plants that once actually lived upon earth,[2] only those know, who are familiar with the history of science. Then it had to be proved, that they are not the wrecks of the Mosaic deluge, which, for a time, was the prevailing opinion, even among scientific men.[3] After Cuvier had shown, beyond question, that they are the remains of animals no longer to be found upon earth, among the living, Palæontology acquired for the first time a solid basis. Yet what an amount of labor it has cost to ascertain, by direct evidence, how these remains are distributed in the solid crust of our globe, what are the differences they exhibit in successive formations,[4] what is their geographical distribution, only those can

(H. G.,) Index palæontologicus, Stuttgart, 1848–49, 3 vols. 8vo. — See also, KEFERSTEIN, (CHR.,) Geschichte und Literatur der Geognosie, Halle, 1840, 1 vol. 8vo. — ARCHIAC, (VIC. D',) Histoire des progrès de la Géologie, Paris, 1847, et suiv, 4 vols. 8vo.; and the Transactions, Journals, and Proceedings of the Geological Society of London, of Paris, of Berlin, of Vienna, etc.; also, LEONHARD and BRONN's Neues Jahrbuch, etc.

[1] AGASSIZ's Geological Times, etc., q. a., p. 25, note 2. — DANA's Address to the Amer. Ass. for Adv. Sc. 8th Meeting, held at Providence, 1855.

[2] SCILLA, (AG.,) La vana speculazione desingannata dal senso. Napoli, 1670, 4to. fig.

[3] SCHEUCHZER, (J. J.,) Homo Diluvii testis et *θεόσκοπος*, Tiguri, 1726, 4to. — BUCKLAND, (W.,) Reliquiæ diluvianæ, or Observations on the Organic Remains attesting the Action of an Universal Deluge, London, 1826, 4to. fig.

[4] For references respecting the fossils of the oldest geological formations, see the works, quoted above, p. 23, note 1. Also, MCCOY, (F.,) Synopsis of the Silurian Fossils of Ireland, Dublin, 1846, 4to. fig. — GEINITZ, (H. D.,) Die Versteinerungen der Grauwackenformation, Leipzig, 1850–53, 4to. fig. — And for local information, the geological reports of the different States of the Union, a complete list of which, with a summary of the Geology, may be found in MARCOU's (J.,) Résumé explicatif d'une carte géologique des Etats-Unis, Bull. Soc. Géol. de France, Paris, 1855, 2de sér. vol. 12. — For the *Devonian system:* PHILLIPS, (JOHN,) Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and Westsomerset, etc., London, 1841, 8vo. — ARCHIAC, (VIC. D',) and VERNEUIL, (ED. DE,) Memoir on the Fossils of the Older Deposits in the Rhenish Provinces, Paris, 1842, 4to. fig. — SANDBERGER, (G. UND FR.,) Systematische Beschreibung

fully appreciate, who have had a hand in the work.[1] And even now, how many important questions still await an answer!

und Abbildung der Versteinerungen des Rheinischen Schichtensystems in Nassau, Wiesbaden, 1850–54, 4to. fig. — For the *Carboniferous period:* Phillips, (J.,) Illustrations of the Geology of Yorkshire, London, 1836, 2d vol., 4to. fig. — DeKoninck, (L.,) Descriptions des animaux fossiles qui se trouvent dans le terrain houiller de la Belgique, Liège, 1842, 2 vols. 4to. fig.; suppl., etc. — McCoy, (Fr.,) Synopsis of the Carboniferous Fossils of Ireland, Dublin, 1844, 4to. fig. — Germar, (E. Fr.,) Die Versteinerungen des Steinkohlengebirges, Halle, 1844–53, fol. fig. — Geinitz, (H. B.,) Die Versteinerungen der Steinkohlenformation, Leipzig, 1855, fol. fig. — For the *Permian system:* Quenstedt, (A.,) Ueber die Identität der Petrificate des Thüringischen und Englischen Zechsteins, Wiegman's Archiv, 1835, I., p. 75. — Geinitz, (H. B.,) und Gutbier, (A.,) Die Versteinerungen des Zechsteingebirges, etc., Dresden, 1849, 4to. fig. — King, (W.,) Monograph of the Permian Fossils of England, (Palæont. Soc.,) London, 1850, 4to. fig. — For the *Triasic system:* Alberti, (Fr. v.,) Beitrag zur einer Monographie des bunten Sandsteins, Mushelkalks, und Keupers, Stuttgart und Tübingen, 1834, 8vo. — For the *Jura,* Phillips, (J.,) Illustrations of the Geology of Yorkshire, York, 1829, vol. 1, 4to. fig. — Pusch, (G. G.,) Polens Palæontologie, etc., Stuttgart, 1836, 4to. fig. — Römer, (Fr. A.,) Die Versteinerungen des norddeutschen Oolithen-Gebirges, Hannover, 1836, 4to. fig. — Zieten, (C. H. v.,) Die Versteinerungen Würtembergs, Stuttgart, 1830–34, fol. fig. — Oribgny, (Alc. d',) Paléontologie française, Paris, 1840–53, 8vo. fig. — Morris, (J.,) and Lycett, (J.,) Mollusca from the Great Oolite, (Palæont. Soc.,) London, 1850–55, 4to. fig. — For the *Cretaceous period:* Morton, (S. G.,) Synopsis of the Remains of the Cretaceous Group of the United States, Philadelphia, 1834, 8vo. fig. — Orbigny, (Alc. d',) Paléont. franç., q. a. — Geinitz, (H. Br.,) Charakteristik der Schichten und Petrefakten des Kreidegebirges, Dresden, 1839–42, 4to. fig. — Pictet, (F. J.,) et Roux, (W.,) Description des fossiles qui se trouvent dans les grès verts des environs de Genève, Mém. Soc. Phys., etc., Genève, 1847–52, vol. 12 et 13. — Römer, (F. A.,) Die Versteinerungen des norddeutschen Kreidegebirges, Hannover, 1841, 4to. fig. — Die Kreidebildungen von Texas, Bonn, 1852, 4to. fig. — Reuss, (A. E.,) Die Versteinerungen der böhmischen Kreideformation, Stuttgart, 1845–46, 4to. fig. — Müller, (Jos.,) Monographie der Petrefacten der Aachener Kreideformation, Bonn, 1851, 4to. fig. — Sharpe, (D.,) Fossil Remains of Mollusca found in the Chalk of England, (Palæont. Soc.,) London, 1854, 4to. fig. — Hall, (James,) Cretaceous Fossils of Nebraska, Trans. Amer. Acad., 1856, vol. 5. — For the *Tertiaries:* Brocchi, (G. B.,) Conchiologia fossile subappennina, etc., Milano, 1814–43, 2 vols., 4to. fig. — DesHayes, (G. P.,) Description des coquilles fossiles des environs de Paris, 1824–37, 3 vols. 4to. Atl. — Bronn, (H. G.,) Italiens Tertiärgebilde, Heidelberg, 1831, 8vo. — Lea, (I.,) Contributions to Geology, Philadelphia, 1833, 8vo. fig. — Conrad, (T. A.) Fossil Shells of the Tertiary Formations of North America, Philadelphia, 1832–36, 8vo. fig. — Grateloup, (Dr.,) Conchyliologie fossile du bassin de l'Adour, etc., Bordeaux, 1837, 8vo. fig. — Matheron, (Ph.,) Catalogue méthodique et descriptif des corps organisés fossiles, etc., Marseilles, 1842, 8vo. — Berendt, (G. C.,) Organische Reste im Bernstein, Berlin, 1845–54, fol. fig. — Wood, (S. V.,) A Monograph of the Crag Mollusks, (Palæont. Soc.,) 1848–50, 4to. fig. — Edwards, (F. E.,) Eocene Mollusca, (Palæont. Soc.,) London, 1849–52, 4to. fig. — Hörness, (M.,) Die fossilen Mollusken des Tertiär-Beckens von Wien, Wien, 1851, 4to. fig. — Beyrich, (E.,) Die Conchylien des norddeutschen Tertiärgebirges, Berlin, 1854–56, 8vo. fig. — Tuomey, (M.,) and Holmes, (Fr. S.,) Fossils of South Carolina, Charleston, 1855–56, 4to. fig.

[1] Buch, (L. v.,) Pétrifications recueillies en Amérique par Mr. Alex. de Humboldt et par Mr. Ch. Degenhard, Berlin, 1838, fol. fig. — Orbigny, (Alc. d',) Voyage dans l'Amérique Méridionale, etc., Paris, 1834–43, 7 vols. 8vo. Atl. 4to. — Archiac,

One result, however, stands now unquestioned: the existence during each great geological era[1] of an assemblage of animals and plants differing essentially for each period. And by period I mean those minor subdivisions in the successive sets of beds of rocks, which constitute the stratified crust of our globe, the number of which is daily increasing, as our investigations become more extensive and more precise.[2] What remains to be done, is to ascertain with more and more precision, the true affinities of these remains to the animals and plants now living, the relations of those of the same period to one another, and to those of the preceding and following epochs, the precise limits of these great eras in the development of life, the character of the successive changes the animal kingdom has undergone, the special order of succession of the representatives of each class,[3] their combina-

(VIC. d',) et HAIME, (J.,) Description des animaux fossiles du groupe nummulitique de l'Inde, Paris, 1853, 4to. fig. — LEUCKART, (F. S.,) Ueber die Verbreitung der übriggebliebenen Reste einer vorweltlichen Schöpfung, Freiburg, 1835, 4to.

[1] Geological text-books: DELABECHE, (Sir H. T.,) Geological Manual, London, 1833, 1 vol. 8vo.; German Trans. by Dechen; French by Brochant de Villers. — The Geological Observer, London, 1851, 8vo. — LYELL, (Sir C.,) Manual of Elementary Geology, London, 1851, 1 vol. 8vo. — Principles of Geology, etc., London, 1830, 2 vols. 8vo.; 8th edit., 1850, 1 vol. 8vo. — NAUMANN, (C. FR.,) Lehrbuch der Geognosie, Leipzig, 1850–54, 2 vols. 8vo. Atl. 4to. — VOGT, (C.,) Lehrbuch der Geologie und Petrefaktenkunde, Braunschweig, 1854, 8vo. 2 vols., 2d edit. — Text-books on Fossils: BRONN, (H. G.,) Lethæa Geognostica, Stuttgart, 1835–37, 2 vols., 8vo. Atl. fol.; 3d edit. with FR. RÆMER, 1846, et seq. — PICTET, (F. J.,) Traité élémentaire de Paléontologie, etc., Paris, 1844–45, 4 vols., 8vo. fig.; 2de édit. 1853 et seq., 8vo. Atl. 4to. — ORBIGNY, (ALC. d',) Cours élémentaire de Paléontologie, Paris, 1852, 3 vols., 12mo. — GIEBEL, (E. G.,) Fauna der Vorwelt, Leipzig, 1852, 2 vols. 8vo. — Allgemeine Palæontologie, Leipzig, 1852, 1 vol., 8vo. — QUENSTEDT, (F. A.,) Handbuch der Petrefaktenkunde, Tübingen, 1852, 8vo. fig. Unfortunately, there exists not a single English text-book of Palæontology. A translation of Pictet's and Bronn's works would be particularly desirable.

[2] At first, only three great periods were distinguished, the primary, the secondary, and the tertiary; afterwards, six or seven, (DelaBèche); later, from ten to twelve; now, the number is almost indefinite, at least undetermined in the present stage of our knowledge, when many geologists would only consider as subdivisions of longer periods, what some palæontologists are inclined to consider as distinct periods.

[3] The principal Monographs relating to special classes or families, are the following; *Polyps* and *Infusoria*: MICHELIN, (H.,) Iconographie Zoophytologique, Paris, 1841–45, 4to. fig. — EDWARDS, (H. MILNE,) et HAIME, (J.,) Recherches, etc., q. a., p. 31. — Polypiers fossiles des terrains paléozoiques, Arch. Mus., vol. 5. — Monograph of the British Fossil Corals, Palæont. Soc., London, 1850–55, 4to. fig. — LONSDALE, (W.,) On the Corals from the Tertiary Formations of North America, Journ. Geol. Soc., I., p. 495; Sill. Journ., 2d ser. IV., p. 357. — MCCOY, (FR.,) Contributions to British Palæontology, Cambridge, 1854, 1 vol. 8vo. fig. — References to all minor papers may be found in Edwards and Haime's Recherches. — EHRENBERG, (C. G.,) Mikrogeologie, Leipzig, 1854, fol. fig. — *Echinoderms:* MILLER, (J. C.,) A Natural History of the Crinoidea, Bristol, 1821, 4to. fig. — ORBIGNY, (ALC. D',) Histoire naturelle générale et particulière des Crinoides vivans et fossiles, Paris, 1840, 4to. fig. — AUSTIN, (TH. and TH. Jr.,) Monograph on Recent and Fossil Crinoidea, Bristol, 4to. fig. (without date.) — HALL, (J.,)

tions into distinct faunæ during each period, not to speak of the causes, or even the circumstances, under which these changes may have taken place.

Palæont. of New York, q. a. — GOLDFUSS, (G. A.,) Petref. Germ., q. a. — DEKONINCK, (L.,) et LEHON, (H.,) Recherches sur les Crinoides, etc., Bruxelles, 1854, 4to. fig. — OWEN, (D. D.,) and SHUMARD, (B. F.,) Description of New Species of Crinoidea, Journ. Ac. Nat. Sc., Philad. 1850, 4to. fig. — SISMONDA, (E.,) Monographia degli Echinidi fossili del Piemonte, Torino, 1840, 4to. fig. — DESMOULINS, (C.,) Etude sur les Echinides, Bordeaux, 1835–37, 8vo. fig. — AGASSIZ, (L.,) Monogr. Echin., q. a., p. 54. — Catalogue raisonné, etc., q. a., p. 31. I quote this paper under my name alone, because that of Mr. Desor, which is added to it, has no right there. It was added by him, after I had left Europe, not only without authority, but even without my learning it, for a whole year. The genera Goniocidaris, Mespilia, Boletia, Lenita, Gualteria, Lovenia, Breynia, which bear his name, while they should bear mine, as I have established and named them, while Mr. Desor was travelling in Sweden, were appropriated by him, without any more right, by a mere dash of the pen, while he was carrying my manuscript through the press. How many species he has taken to himself, in the same manner, I cannot tell. As the printed work, and a paper presented by me to the Academy of Sciences of Paris, in 1846, exhibit, for every one acquainted with zoölogical nomenclature, internal evidence of my statement, such, for instance, as my name left standing as authority for the species of Mespilia, Lenita, Gualteria, and Breynia, while the genus bears his, I need not allude further to the subject. This is one of the most extraordinary cases of plagiarism I know of. — DESOR, (E.,) Synopsis des Echinides fossiles, Paris, 1854–56, 8vo. fig.; partly reprinted from my Catalogue, with additions and figures. — BUCH, (L. v.,) Ueber die Cystideen, Berlin, 1844, 4to. fig.; Ak. d. wiss. — MÜLLER, (J.,) Ueber den Bau der Echinodermen, Berlin, 1854, 4to. fig. — ROEMER, (F.,) Ueber Stephanocrinus, etc., Wiegm. Arch., 1850, p. 365. — Monographie der fossilen Crinoidenfamilie der Blastoideen, etc., Wiegm. Arch., 1851, p. 323. — FORBES, (ED.,) Echinodermata of the British Tertiaries, (Palæont. Soc.,) 1852, 4to. fig. — Mem. of the Geol. Surv. of the Unit. Kingdom, London, 1849, 8vo. fig., Dec. 1st, 3d, and 4th. — *Mollusks:* DESHAYES, (G. P.,) Traité élémentaire de Conchyliologie, etc., Paris, 1835–39, 2 vols. 8vo. fig. — Description des coquilles caractéristique des terrains, Paris, 1831, 8vo. fig. — WOODWARD, (S. P.,) A Manual of the Mollusca, etc., London, 1851–54, 12mo. fig. — HAGENOW, (FR. v.,) Die Bryozoen der Maastrichter Kreideformation, Cassel, 1851, 4to. fig. — DESMOULINS, (C.,) Essai sur les Sphérulites, Bull. Soc. Lin., Bordeaux, 1827. — ROQUAN, (O. R. DU,) Description des Coquilles fossilles de la famille des Rudistes, etc., Carcassonne, 1841, 4to. fig. — HOENINGHAUS, (FR. W.,) Monographie der Gattung Crania, Düsseldorf, 1828, 4to. fig. — BUCH, (L. v.,) Ueber Terebrateln, etc., Berlin, 1834, 4to. fig.; Ak. d. wiss. — Ueber Productus und Leptæna, Berlin, 1842, 4to. fig.; Ak. d. wiss. — DAVIDSON, (TH.,) British Brachiopoda, (Palæont. Soc.,) London, 1851–55, 4to. fig. — DEKONINCK, (L.,) Recherches sur les animaux fossiles, Liège, 1847, 4to. fig. — AGASSIZ, (L.,) Etudes crit. q. a., p. 54. — FAVRE, (A.,) Observations sur les Dicerates, Genève, 1843, 4to. fig. — BELLARDI, (L.,) e MICHELOTTI, (G.,) Saggio orittografico sulla classe dei Gasteropodi fossili, Torino, 1840, 4to. fig. — DEHAAN, (W.,) Monographiæ Ammoniteorum et Goniatiteorum Specimen, Lugduni-Batav., 1825, 8vo. — BUCH, (L. v.,) Ueber Ammoniten, über ihre Sonderung in Familien, etc., Berlin, 1832, 4to. fig. Ak. d. wiss. — Ueber Goniotiten und Clymenien in Schlesien, Berlin, 1839, 4to. fig.; Ak. d. wiss. — MÜNSTER, (GR. v.,) Ueber Goniatiten und Planuliten im Uebergangskalk, etc., Baireuth, 1832, 4to. fig. — VOLTZ, (PH. L.,) Observations sur les Bélemnites, Paris, 1830, 4to. fig. — QUENSTEDT, (F. A.,) De Notis Nautileorum primariis, etc., Berolini, 1834, 8vo. — *Crustacea:* BRONGNIART, (AL.,) et DESMAREST, (A. G.,) Histoire naturelle des Trilobites, etc., Paris, 1822, 4to. fig. — DALMAN, (J. W.,) Ueber die Palæaden oder die sogenannten Trilobiten, a. d. Schwed., Nürnberg,

In order to be able to compare the order of succession of the animals of past ages with some other prominent traits of the animal kingdom, it is necessary for

1828, 4to. fig. — GREEN, (J.,) A Monograph of the Trilobites of North America, etc., Philadelphia, 1833, 8vo. fig. — EMMERICH, (H. F.,) De Trilobitis, Berolini, 1839, 8vo. fig. — Zur Naturgeschichte der Trilobiten, Meiningen, 1844, 4to. — BURMEISTER, (H.,) Die Organisation der Trilobiten, Berlin, 1843, 4to. fig.; (Ray Society.) — BEYRICH, (E.,) Ueber einige böhmische Trilobiten, Berlin, 1845, 4to.; 2d part, 1846, 4to. — CORDA, (A. J. C.,) und HAWLE, (IG.,) Prodrom einer Monographie der böhmischen Trilobiten, Prag, 1848, 8vo. fig. — BARRANDE, (J.,) Syst. Sil., q. a., p. 23. — SALTER, (J. W.,) In Mem. Geol. Surv., etc., Dec. 2d. — MÜNSTER, (GR. G. v.,) Beiträge zur Petrefaktenkunde, Beyreuth, 1839, 4to. 2d Fasc., fig. — MEYER, (H. v.,) Neue Gattungen fossiler Krebse, etc., Stuttgart, 1840, 4to. fig. — DE KONINCK, (L.,) Mémoire sur les Crustacés fossiles de Belgique, Liège, 1841, 4to. fig. — CORNUEL, (J.,) Description des Entomostracés fossiles, etc., Mém. Soc. Géol. de France, 2de sér., vol. 1, part 2d, Paris, 1846, 4to. fig. — BOSQUET, Description des Entomostracés fossiles de la Craie de Mæstricht, Mém. Soc. Roy. de Liège, 1847, 8vo. — JONES, (T. R.,) The Entomostraca of the Cretaceous Formation of England, (Palæont. Soc.,) London, 1848, 4to. fig. — DARWIN, (CH.,) Fossil Cirripedia, (Palæont. Soc.,) London, 1851 and 1854, 4to. fig. — *Insects:* BRODIE, (P. B.,) History of the Fossil Insects of the Secondary Rocks of England, London, 1845, 8vo. — HEER, (O.,) Die Insektenfauna der Tertiärgebilde von Oeningen und von Radeboy, Leipzig, 1853, 4to. fig.; N. DENK., helv. Gessellsch. — HEER, (O.,) et ESCHER v. DER LINTH, (A.,) Zwei geologische Vorträge, etc., Zürich, 1852, 4to. — *Fishes:* AGASSIZ, (L.,) Rech. s. les poiss. foss., q. a., p. 54. — EGERTON, (SIR PHIL.,) A Systematic and Stratigraphical Catalogue of the Fossil Fishes, etc., London, 1837, 4to. 2d edit. — On some new Ganoid Fishes, Proc. Geol. Soc. London, IV., p. 183. — On some New Species of Chimæroid Fishes, Ibid., p. 153 and 211, and several other papers in Trans. Geol. Soc. Lond.; Journ. Geol. Soc.; Ann. and Mag. Nat. Hist., and Memoirs of the Geol. Surv. of the United Kingdom, Dec. 6th. — PICTET, (F. J.,) Poissons fossiles du Mt. Liban, Genève, 1850, 4to. fig. — HECKEL, (J. J.,) Beiträge zur Kenntniss der fossilen Fische Oesterreichs, Wien, 1849, 4to. fig. — GIBBES, (R. W.,) Monograph of the Fossil Squalidæ of the United States, Journ. Ac. Nat. Sc., Philadelphia, 1848 and 1849, 4to. fig. — New Species of Myliobates, Ibid., 1849, p. 299. — MCCOY, (F.,) In Sedgwick and McCoy's British Palæoz. Rocks, q. a., p. 23. — NEWBERRY, (J. S.,) Fishes of the Carbonif. Deposits of Ohio, Proc. Ac. Nat. Sc., Philadelphia, 1856. — *Reptiles:* CUVIER, (G.,) Rech. Oss. foss., q. a., p. 93. — JAEGER, (G. FR.,) Ueber die fossilen Reptilien welche in Würtemberg aufgefunden worden sind, Stuttgart, 1828, 4to. fig. — GEOFFROY ST. HILAIRE, (ET.,) Recherches sur les grands Sauriens, etc., Paris, 1831, 4to. fig. — DESLONGCHAMPS, (EUD.,) Mém. sur le Poecilopleuron Bucklandi, Caen, 1837, 4to. fig. — BRONN, (H. G.,) und KAUP, (J. J.,) Abhandlungen über die Gavialartigen Reptilien, Stuttgart, 1842, fol. fig. — GOLDFUSS, (A.,) Der Schädelbau des Mosasaurus, N. Act. Ac. Nat. Car., 1844, 4to. fig. — ALTON, (E. D',) und BURMEISTER, (H.,) Der fossile Gavial von Boll, Halle, 1854, fol. fig. — BURMEISTER, (H.,) Die Labyrinthodonten, Berlin, 1850, 4to. fig. — QUENSTEDT, (A.,) Die Mastodonsaurier sind Batrachier, Tübingen, 1850, 4to. fig. — GIBBES, (R. W.,) A Memoir on Mosasaurus and three New Genera, etc., Smithson. Contrib. 1851, 4to. fig. — MEYER, (H. v.,) Zur Fauna der Vorwelt, Die Saurier des Muschelkalkes, etc., Frankfurt a. M., 1845–52, fol. — MEYER, (H. v.,) und PLIENINGER, (TH.,) Beiträge zur Palæontologie Würtembergs, Stuttgart, 1844, 4to. fig. — OWEN, (R.,) Report on British Fossil Reptiles, Brit. Ass. 1839, p. 43; 1841, p. 60. — Fossil Reptilia of the London Clay, (Palæont. Soc.,) London, 1849, 4to. fig. (the Chelonia with T. BELL.) — Fossil Reptilia of the Cretaceous Formation, (Palæont. Soc.,) London, 1851, 4to. fig. — Fossil Reptilia of the Wealden Formation, (Palæont. Soc.,) London, 1852–55, 4to. fig. — LEA, (I.,) On a Fossil Saurian of the New

me to make a few more remarks upon this topic. I can, fortunately, be very brief, as we possess a text-book of Palæontology, arranged in zoölogical order, in which every one may at a glance see how, throughout all the classes of the animal kingdom, the different representatives of each, in past ages, are distributed in the successive geological formations.[1] From such a cursory survey, it must appear, that while certain types prevail during some periods, they are entirely foreign to others. This limitation is conspicuous, with reference to entire classes among Vertebrata, while, in other types, it relates more to the orders, or to the families, and extends frequently only to the genera or the species. But, whatever be the extent of their range in time, we shall see presently, that all these types bear, as far as the order of their succession is concerned, the closest relation to the relative rank of living animals of the same types compared with one another, to the phases of the embryonic growth of these types in the present day, and even to their geographical distribution upon the present surface of our globe. I will, however, select

Red Sandstone, etc., Philadelphia, 1852, 4to. fig. — Leidy, (Jos.,) Description of Extinct Mammalia and Chelonia from Nebraska Territory, in D. D. Owen, Geol. Surv. of Wisconsin, Iowa, Minesota, etc., Philadelphia, 1852, 4to. fig. — On Bathygnathus borealis, an extinct Saurian, Journ. Ac. Nat. Sc., Philad., 1854, 4to. fig. — Description of a New Species of Crocodile, etc., Ibid., 1851. — *Birds:* Owen, (R.,) History of British Fossil Mammalia and Birds, London, 1844–46, 1 vol. 8vo. fig. — Fossil Birds from the Wealden, Journ. Geol. Soc., II., p. 96. — Memoir on the Dinornis, Trans. Zool. Soc., vol. 3, p. 3, London, 1844, 4to. fig. — *Mammalia*: Cuvier, (G.,) Oss. foss., q. a. — Buckland, (W.,) Rel. Diluv., q. a., p. 94. — DeBlainville, (Ducr.,) Ostéographie ou Description iconographique comparée du Squelette, etc., Paris, 1841, et suiv. 4to., Atlas fol. — Kaup, (J. J.,) Descriptions d'ossemens fossiles de Mammifères inconnus, Darmstadt, 1832–39, 4to. fig. — Owen, (R.,) Odontography, or a Treatise on the Comparative Anatomy of the Teeth, London, 1840–41, 3 vols. 8vo. fig. — Brit. foss. Mam. and Birds, q. a. — The Fossil Mammalia of the Voyage of H. M. S. Beagle, London, 1838, 4to. fig. — Description of the Skeleton of an extinct gigantic Sloth, Mylodon robustus, London, 1842, 4to. fig.; and many papers in Journal of Geological Society; Trans. Zool. Society, etc. — Schmerling, (P. C.,) Recherches sur les ossemens fossiles des cavernes de Liège, Liège, 1833–36, 2 vols. 4to. fig. — Croizet et Jobert, Recherches sur les ossemens fossiles du département du Puy-de-Dôme, Paris, 1828, fol. fig. — Meyer, (H. v.,) Zur Fauna, etc., q. a. — Die fossilen Zähne und Knochen, in der Gegend von Georgensgmünd, Frankfurt a. M., 1834, 4to. fig. — Jaeger, (G. Fr.,) Die fossilen Säugethiere Würtembergs, Stuttgardt, 1835–39, fol. fig. — Falconer, (H.,) and Cautley, (P. T.,) Fauna antiqua sivalensis, etc., London, 1846, fol. fig. — Gervais, (P.,) Zoologie et Paléontologie françaises, Paris, 1848–52, 4to. fig. — Müller, (J.,) Ueber die fossilen Reste der Zeuglodonten, etc., Berlin, 1849, fol. fig. — LeConte, (J.,) On Platygonus compressus, Mem. Amer. Acad. Arts and Sc., 1848, 4to. fig. — Wyman, (J.,) Notice of the Geological Position of Castoroides ohioensis, by J. Hall, and an Anatomical Description of the same, Boston Journ. Nat. Hist., 1847, vol. 5, p. 385, 8vo. fig. — Warren, (J. C.,) Description of a Skeleton of the Mastodon giganteus, Boston, 1852, 4to. fol. — Leidy, (J.,) The Ancient Fauna of Nebraska, Smith. Contr., Washington, 1852, 4to. fig. See also Sect. 22.

[1] I allude to the classical work of Pictet, Traité élémentaire de Paléontologie, q. a., a second edition of which is now publishing.

a few examples for further discussion. Among Echinoderms the Crinoïds are, for a long succession of periods, the only representatives of that class; next follow the Starfishes, and next the Sea-Urchins, the oldest of which belong to the type of Cidaris and Echinus, followed by Clypeastroids and Spatangoids. No satisfactory evidence of the existence of Holothuriæ has yet been found. Among Crustacea, a comparison of the splendid work of Barrande[1] upon the Silurian System of Bohemia, with the paper of Count Münster upon the Crustacea of Solenhofen,[2] and with the work of Desmarest upon fossil Crabs,[3] will at once show that while Trilobites are the only Crustacea of the oldest palæozoic rocks, there is found in the jurassic period a carcinological fauna entirely composed of Macrura, to which Brachyura are added in the tertiary period. The formations intermediate between the older palæozoic rocks and the Jura contain the remains of other Entomostraca, and later of some Macroura also. In both classes the succession of their representatives, in different periods, agrees with their respective standing, as determined by the gradation of their structure.

Among plants, we find in the Carboniferous period prominently, Ferns and Lycopodiaceæ;[4] in the Triassic period Equisetaceæ[5] and Coniferæ prevail; in the Jurassic deposits, Cycadeæ,[6] and Monocotyledoneæ; while later only Dicotyledoneæ take the lead.[7] The iconographic illustration of the vegetation of past ages has of late advanced beyond the attempts to represent the characteristic features of the animal world in different geological periods.[8]

Without attempting here to characterize this order of succession, this much follows already from the facts mentioned, that while the material world is ever the same through all ages in all its combinations, as far back as direct investigations can trace its existence, organized beings, on the contrary, transform these same materials into ever new forms and new combinations. The carbonate of lime of all ages is the same carbonate of lime in form as well as composition, as long as it is under the action of physical agents only. Let life be introduced upon earth,

[1] BARRANDE's Syst. Silur., q, a., p. 23.

[2] GR. G. v. MÜNSTER, Beiträge zur Petrefactenkunde, q. a., p. 98.

[3] DESMAREST, see Brongniart and Desmarest's Hist. Nat. d. Tril. et Crust., q. a., p. 97.

[4] See, above, p. 93.

[5] SCHIMPER, (W. P.,) et MOUGEOT, (A.,) Monographie des Plantes Fossiles du Grès-bigarré de la chaine des Vosges, Strasb. et Paris, 1840–43, 4to. fig.

[6] BUCKLAND, (W.,) On the Cycadeoidæ, a Family of Plants found in the Oolite, etc., Trans. Geol. Soc. Lond. 2d ser. II., p. 395.

[7] UNGER, (FR.,) Chloris protogæa, Beiträge zur Flora der Vorwelt, Leipzig, 1841, 4to. fig. — HEER, (O.,) Flora tertiaria Helvetiæ, Wintherthur, 1855, fol. fig.

[8] Landscapes of the different geological periods are represented in UNGER, (FR.,) Die Vorwelt in ihren vershiedenen Bildungsperioden, Wien, fol. (no date.) These landscapes are ideal representations of the vegetation of past ages.

and a Polyp builds its coral out of it, and each family, each genus, each species a different one, and different ones for all successive geological epochs. Phosphate of lime in palæozoic rocks is the same phosphate, as when prepared artificially by Man; but a Fish makes its spines out of it, and every Fish in its own way, a Turtle its shield, a Bird its wings, a Quadruped its legs, and Man, like all other Vertebrates, its whole skeleton, and during each successive period in the history of our globe, these structures are different for different species. What similarity is there between these facts! Do they not plainly indicate the working of different agencies excluding one another? Truly the noble frame of Man does not owe its origin to the same forces which combine to give a definite shape to the crystal. And what is true of the carbonate of lime, is equally true of all inorganic substances; they present the same characters in all ages past, as those they exhibit now.

Let us look upon the subject in still another light, and we shall see that the same is also true of the influence of all physical causes. Among these agents, the most powerful is certainly electricity; the only one to which, though erroneously, the formation of animals has ever been directly ascribed. The effects it may now produce, it has always produced, and produced them in the same manner. It has reduced metallic ores and various earthy minerals and deposited them in crystalline form, in veins, during all geological ages; it has transported these and other substances from one point to another, in times past, as we may do now in our laboratories, under its influence. Evaporation upon the surface of the earth has always produced clouds in the atmosphere, which after accumulating have been condensed in rain showers in past ages as now. Rain drop marks in the carboniferous and triassic rocks have brought to us this testimony of the identity of the operation of physical agents in past ages, to remind us that what these agents may do now, they already did in the same way, in the oldest geological times, and have done at all times. Who could, in presence of such facts, assume any causal connection between two series of phenomena, the one of which is ever obeying the same laws, while the other presents at every successive period new relations, an ever changing gradation of new combinations, leading to a final climax with the appearance of Man? Who does not see, on the contrary, that this identity of the products of physical agents in all ages, totally disproves any influence on their part in the production of these ever changing beings, which constitute the organic world, and which exhibit, as a whole, such striking evidence of connected thoughts!

SECTION XXII.

LOCALIZATION OF TYPES IN PAST AGES.

The study of the geographical distribution of the animals now living upon earth has taught us, that every species of animals and plants has a fixed home, and even that peculiar types may be circumscribed within definite limits, upon the surface of our globe. But it is only recently, since geological investigations have been carried on in remote parts of the world, that it has been ascertained that this special localization of types extends to past ages. Lund for the first time showed that the extinct Fauna of the Brazils,[1] during the latest period of a past age, consists of different representatives of the very same types now prevalent in that continent; Owen has observed similar relations between the extinct Fauna of Australia[2] and the types now living upon that continent.

If there is any naturalist left who believes that the Fauna of one continent may be derived from another portion of the globe, the study of these facts, in all their bearing, may undeceive him.

It is well known how characteristic the Edentata are for the present Fauna of the Brazils, for there is the home of the Sloths, (Bradypus,) the Tatous, (Dasypus,) the Ant-eaters, (Myrmecophaga); there also have been found those extraordinary extinct genera, the Megatherium, the Mylodon, the Megalonyx, the Glyptodon, and the many other genera described by Dr. Lund and Professor Owen, all of which belong to this same order of Edentata. Some of these extinct genera of Edentata had also representatives in North America, during the same geological period,[3] thus showing that though limited within similar areas, the range of this type has been different in different epochs.

Australia, at present almost exclusively the home of Marsupials, has yielded also a considerable number of equally remarkable species, and two extinct genera of that type, all described by Owen in a report to the British Association, in 1844, and in Michell's Expeditions into the Interior of Australia.

[1] LUND, (DR.,) Blik paa Brasiliens Dyreverden för sidste Jordomvæltning. K. Danske Vidensk. Selsk. Afhandl. VIII., Kiöbenhavn, 1841, 4to. fig., p. 61, etc.; Engl. Abstract, Ann. and Mag. vol. 3, p. 422.

[2] OWEN, (R.,) On the Geographical Distribution of Extinct Mammalia, Ann. and Mag. Nat. Hist., 1846, vol. 17, p. 197.

[3] LEIDY, (JOS.,) A Memoir on the Extinct Sloth Tribe of North America, Smithson. Contrib. 1855, 4to. fig. — WYMAN, (J.,) Notice of Fossil Bones, etc., Am. Journ. Sc. and A., 2d ser., 1850, vol. 10.

How far similar facts are likely to occur in other classes, remains to be ascertained. Our knowledge of the geographical distribution of the fossil remains is yet too fragmentary to furnish any further data upon this point. It is, however, worthy of remark, that though the types of the oldest geological periods had a much wider distribution than most recent families exhibit now, some families of fishes largely represented in the Devonian system of the Old World have not yet been noticed among the fossils of that period in America, as, for instance, the Cephalaspids, the Dipteri, and the Acanthodi. Again, of the many gigantic Reptiles of the Triasic and Oolitic periods, none are known to occur elsewhere except in Europe, and it can hardly be simply owing to the less extensive distribution of these formations in other parts of the world, since other fossils of the same formations are known from other continents. It is more likely that some of them, at least, are peculiar to limited areas of the surface of the globe, as, even in Europe, their distribution is not extensive.

Without, however, entering upon debatable ground, it remains evident, that before the establishment of the present state of things, peculiar types of animals, which were formerly circumscribed within definite limits, have continued to occupy the same or similar grounds in the present period, even though no genetic connection can be assumed between them, their representatives in these different formations not even belonging to the same genera. Such facts are in the most direct contradiction with any assumption that physical agents could have any thing to do with their origin; for though their occurrence within similar geographical areas might at first seem to favor such a view, it must be borne in mind that these so localized beings are associated with other types which have a much wider range, and, what is still more significant, they belong to different geological periods, between which great physical changes have undoubtedly taken place. Thus the facts indicate precisely the reverse of what the theory assumes; they prove a continued similarity of organized beings during successive geological periods, notwithstanding the extensive changes, in the prevailing physical conditions, which the country they inhabited may have undergone, at different periods. In whatever direction this theory of the origin of animals and plants, under the influence of physical agents, is approached, it can nowhere stand a critical examination. Only the deliberate intervention of an Intellect, acting consecutively, according to one plan, can account for phenomena of this kind.

SECTION XXIII.

LIMITATION OF SPECIES TO PARTICULAR GEOLOGICAL PERIODS.

Without entering into a discussion respecting the precise limits within which this fact is true, there can no longer be any doubt, that not only species, but all other groups of animals and plants, have a definite range of duration, as well as individuals.[1] The limits of this duration, as far as species are concerned, generally coincide with great changes in the physical conditions of the earth's surface;[2] though, strange to say, most of those investigators who would ascribe the origin of organized beings to the influence of such causes, maintain also, that species may extend from one period to another, which implies that these are not affected by such changes.[3]

When considering, in general, the limitation of species to particular geological periods, we might very properly disregard the question of the simultaneity of the successive appearance and disappearance of Faunæ, as in no way affecting the result of the investigation, as long as it is universally conceded, that there is no species, known among the fossils, which extends through an indefinite series of geological formations. Moreover, the number of the species, still considered as identical in several successive periods, is growing smaller and smaller, in proportion as they are more closely compared. I have already shown, long ago, how widely many of the tertiary species, long considered as identical with living ones, differ from them,[4] and also how different the species of the same family may be, in successive subdivisions of the same great geological formation.[5] Hall has come to the same result in his investigations of the fossils of the State of New York.[6] Every monograph reduces their number, in every formation. Thus Barrande, who has devoted so many years to the most minute investigation of the Trilobites of

[1] Compare Sect. XIX.

[2] ELIE DE BEAUMONT, Recherches sur quelques-unes des Révolutions de la surface du Globe, Paris, 1830, 1 vol. 8vo.

[3] For indications respecting the occurrence of all species of fossil organized beings now known, consult, BRONN, (H. G.,) Index palæontologicus, Stuttgardt, 1848–49, 3 vols. 8vo. — ORBIGNY, (A. D',) Prodrome de Paléontologie stratigraphique universelle etc., Paris, 1850, 2 vols. 12mo. — MORRIS, (J.,) Catalogue of the British Fossils, London, 1854, 1 vol. 8vo.

[4] AGASSIZ, (L.,) Coquilles tertiaires reputées identiques avec les espèces vivantes, Neuchâtel, 1845, 4to. fig.

[5] AGASSIZ, (L.,) Etudes critiques sur les Mollusques fossiles, Neuchâtel, 1840–45, 4to. fig.

[6] HALL, (J.,) Palæontology of the State of New York, q. a., p. 23, note 1.

Bohemia,[1] has come to the conclusion that their species do not extend from one formation to the other; D'Orbigny[2] and Pictet[3] have come to the same conclusion for the fossil remains of all classes. It may well be said that, as fossil remains are studied more carefully, in a zoölogical point of view, the supposed identity of species, in different geological formations, vanishes gradually more and more; so that the limitation of species in time, already ascertained in a general way, by the earlier investigations of their remains in successive geological formations, is circumscribed, step by step, within narrower, more definite, and also more equable periods. Species are truly limited in time, as they are limited in space, upon the surface of the globe. The facts do not exhibit a gradual disappearance of a limited number of species, and an equally gradual introduction of an equally limited number of new ones; but, on the contrary, the simultaneous creation and the simultaneous destruction of entire faunæ, and a coincidence between these changes in the organic world and the great physical changes our earth has undergone. Yet it would be premature to attempt to determine the extent of the geographical range of these changes, and still more questionable to assert their synchronism upon the whole surface of the globe, in the ocean and upon dry land.

To form adequate ideas of the great physical changes the surface of our globe has undergone, and the frequency of these modifications of the character of the earth's surface, and of their coincidence with the changes observed among the organized beings, it is necessary to study attentively the works of Elie de Beaumont.[4] He, for the first time, attempted to determine the relative age of the different systems of mountains, and showed first, also, that the physical disturbances occasioned by their upheaval coincided with the successive disappearance of entire faunæ, and the reappearance of new ones. In his earlier papers he recognized seven, then twelve, afterwards fifteen such great convulsions of the globe, and now he has traced more or less fully and conclusively the evidence that the number of these disturbances has been at least sixty, perhaps one hundred. But while the genesis and genealogy of our mountain systems were thus illustrated, palæontologists, extending their comparisons between the fossils of different formations more carefully to all the successive beds of each great era, have observed more and more marked differences between them, and satisfied themselves that faunæ also have been more frequently renovated, than was formerly supposed; so that the general results of

[1] BARRANDE, Système silurien, etc., q. a.; see, also, my Monographies d'Echinodermes, q. a., p. 54.

[2] D'ORBIGNY, Paléontologie Française, q. a., p. 95.

[3] PICTET, Traité de Paléontologie, etc., q. a., p. 96, note 1.

[4] ELIE DE BEAUMONT, Notice sur les systèmes de Montagnes, Paris, 1852, 3 vols. 12mo.; see, also, BUCH, (LEOP. v.,) Ueber die geognotischen Systeme von Deutschland, Leonhard's Taschenb., 1824, II., p. 501.

geology proper and of palæontology concur in the main to prove, that while the globe has been at repeated intervals, and indeed frequently, though after immensely long periods, altered and altered again, until it has assumed its present condition, so have also animals and plants, living upon its surface, been again and again extinguished and replaced by others, until those now living were called into existence with man at their head. The investigation is not in every case sufficiently complete to show everywhere a coincidence between this renovation of animals and plants and the great physical revolutions which have altered the general aspect of the globe, but it is already extensive enough to exhibit a frequent synchronism and correlation, and to warrant the expectation that it will, in the end, lead to a complete demonstration of their mutual dependence, not as cause and effect, but as steps in the same progressive development of a plan which embraces the physical as well as the organic world.

In order not to misapprehend the facts, and perhaps to fall back upon the idea, that these changes may be the cause of the differences observed between the fossils of different periods, it must be well understood that, while organized beings exhibit through all geological formations a regular order of succession, the character of which will be more fully illustrated hereafter, this succession has been from time to time violently interrupted by physical disturbances, without any of these altering in any way the progressive character of that succession of organized beings. Truly this shows that the important, the leading feature of this whole drama is the development of life,[1] and that the material world affords only the elements for its realization. The simultaneous disappearance of entire faunæ, and the following simultaneous appearance of other faunæ, show further that, as all these faunæ consist of the greatest variety of types,[2] in all formations, combined everywhere into natural associations of animals and plants, between which there have been definite relations at all times, their origin can at no time be owing to the limited influence of monotonous physical causes, ever acting in the same way. Here, again, the intervention of a Creator is displayed in the most striking manner, in every stage of the history of the world.

[1] DANA, (J. D.,) Address, q. a., p. 94, note 1.

[2] AGASSIZ, (L.,) Geol. Times, q. a., p. 25.

SECTION XXIV.

PARALLELISM BETWEEN THE GEOLOGICAL SUCCESSION OF ANIMALS AND PLANTS AND THEIR PRESENT RELATIVE STANDING.

The total absence of the highest representatives of the animal kingdom in the oldest deposits forming part of the crust of our globe, has naturally led to the very general belief, that the animals which have existed during the earliest period of the history of our earth were inferior to those now living, nay, that there is a natural gradation from the oldest and lowest animals to the highest now in existence.[1] To some extent this is true; but it is certainly not true that all animals form one simple series from the earliest times, during which only the lowest types of animals would have been represented, to the last period, when Man appeared at the head of the animal creation.[2] It has already been shown (Sect. VII.) that representatives of all the great types of the animal kingdom have existed from the beginning of the creation of organized beings. It is therefore not in the successive appearance of the great branches of the animal kingdom, that we may expect to trace a parallelism between their succession in geological times and their relative standing at present. Nor can any such correspondence be observed between the appearance of classes, at least not among Radiata, Mollusks, and Articulata, as their respective classes seem to have been introduced simultaneously upon our earth, with perhaps the sole exception of the Insects, which are not known to have existed before the Carboniferous period. Among Vertebrata, however, there appears already a certain coincidence, even within the limits of the classes, between the time of their introduction, and the rank their representatives hold, in comparison to one another. But upon this point more hereafter.

It is only within the limits of the different orders of each class, that the parallelism between the succession of their representatives in past ages and their respective rank, in the present period, is decidedly characteristic. But if this is true, it must be at the same time obvious to what extent the recognition of this correspondence may be influenced by the state of our knowledge of the true affinities and natural gradation of living animals, and that until our classifications have become the correct expression of these natural relations, even the most striking coincidence with the succession of their representatives in past ages may be entirely overlooked. On that account it would be presumptuous on my part to pretend, that I could

[1] See the palæontological works quoted in Sect. 21.

[2] AGASSIZ, (L.,) Twelve Lect., etc., p. 25 and 69.

illustrate this proposition, through the whole animal kingdom, as such an attempt would involve the assertion that I know all these relations, or that where there exists a discrepancy between the classification and the succession of animals, the classification must be incorrect, or the relationship of the fossils incorrectly appreciated. I shall therefore limit myself here to a general comparison, which may, however, be sufficient to show, that the improvements which have been introduced in our systems, upon purely zoölogical grounds, have nevertheless tended to render more apparent the coincidence between the relative standing among living animals and the order of succession of their representatives in past ages. I have lately attempted to show, that the order of Halcyonoids, among Polyps, is superior to that of Actinoids;[1] that, in this class, compound communities constitute a higher degree of development, when contrasted with the characters and mode of existence of single Polyps, as exhibited by the Actinia; that top-budding is superior to lateral budding; and that the type of Madrepores, with their top-animal, or at least with a definite and limited number of tentacles, is superior to all other Actinoids. If this be so, the prevalence of Actinoids in older geological formations, to the exclusion of Halcyonoids, the prevalence of *Rugosa* and *Tabulata* in the oldest deposits,[2] the later prevalence of Astræoids, and the very late introduction of Madrepores, would already exhibit a correspondence between the rank of the living Polyps and the representatives of that class in past ages, though we may hardly expect a very close coincidence in this respect between animals the structure of which is so simple.

The gradation among the orders of Echinoderms is perfectly plain. Lowest stand the Crinoids, next the Asterioids, next the Echinoids, and highest the Holothurioids. Ever since this class has been circumscribed within its natural limits, this succession has been considered as expressing their natural relative standing, and modern investigations respecting their anatomy and embryology, however extensive, have not led to any important change in their classification, as far as the estimation of their rank is concerned. This is also precisely the order in which the representatives of this class have successively been introduced upon earth in past geological ages. Among the oldest formations we find pedunculated Cinoids[3] only, and this order remains prominent for a long series of successive periods; next come free Crinoids and Asterioids; next Echinoids,[4] the successive appearance of which since the triasic

[1] For classification of Polypi, see DANA, q. a., p. 31, note 2; also MILNE-EDWARDS and HAIME, q. a., and AGASSIZ, (L.,) Classification of Polyps, Proc. Am. Acad. Sc. and Arts, 1856, p. 187.

[2] See MILNE-EDWARDS and HAIME, q. a., p. 31.

[3] MILLER, Crinoids, q. a. — D'ORBIGNY, q. a. — J. HALL, q. a. — AUSTIN, q. a., p. 96.

[4] See the works q. a., p. 96; also: MÜLLER, (J.,) and TROSCHEL, (F. H.,) System der Asteriden, Braunschweig, 1842, 4to. fig. — MÜLLER, (J.,) Ueber den Bau der Echinodermen, Berlin, 1854, 4to. — TIEDEMAN, (FR.,) Anatomie der Röhren-Holothurie, des Seeigels, etc., Landshut, 1817, fol. fig. — VALENTIN, (G.,) Anat. du gerne Echinus, Neuchâtel, 1842, 4to.

period to the present day, coincides also with the gradation of their subdivisions, as determined by their structure; and it was not until the present period, that the highest Echinoderms, the Holothurioids, have assumed a prominent position in their class.

Among Acephala there is not any more uncertainty respecting the relative rank of their living representatives, than among Echinoderms. Every zoölogist acknowledges the inferiority of the Bryozoa and the Brachiopods[1] when compared with the Lamellibranchiata, and among these the inferiority of the Monomyaria in comparison with the Dimyaria would hardly be denied. Now if any fact is well established in Palæontology, it is the earlier appearance and prevalence of Bryozoa and Brachiopods in the oldest geological formations, and their extraordinary development for a long succession of ages, until Lamellibranchiata assume the ascendency which they maintain to the fullest extent at present. A closer comparison of the different families of these orders might further show how close this correspondence is through all ages.

Of Gasteropoda I have nothing special to say, as every palæontologist is aware how imperfectly their remains have been investigated in comparison with what has been done for the fossils of other classes. Yet the Pulmonata are known to be of more recent origin than the Branchifera, and among these the Siphonostomata to have appeared later than the Holostomata, and this exhibits already a general coincidence between their succession in time and their respective rank.

Our present knowledge of the anatomy of the Nautilus, for which science is indebted to the skill of Owen,[2] may satisfy everybody that among Cephalopods the Tetrabranchiata are inferior to the Dibranchiata; and it is not too much to say, that one of the first points a collector of fossils may ascertain for himself, is the exclusive prevalence of the representatives of the first of these types in the oldest formations, and the later appearance, about the middle geological ages, of representatives of the other type, which at present is the most widely distributed.

Of Worms, nothing can be said of importance with reference to our inquiry;

[1] ORBIGNY, (A. D',) Bryozoires, Ann. Sc. Nat., 3e sér. 1851, vol. 16, p. 292. — CUVIER, (G.,) Mémoire sur l'animal de la Lingule, Ann. Mus. I., p. 69, fig. — VOGT, (C.,) Anatomie der Lingula anatina, N. Mém. Soc. Helv. 1843, VII., 4to. fig. — OWEN, (R.,) On the Anatomy of the Brachiopoda, Trans. Zool. Soc., I. 4to., p. 145, fig.— On the Anatomy of the Terebratula, 1853, 4to. fig. (Palæont. Soc.)—BUCH, (L. v.,) Ueber Terebrateln, q. a., p. 97.—DAVIDSON, (TH.,) Monogr. etc., q. a., p. 97. — POLI (XAV.,) Testacea utriusque Siciliæ, eorumque Historia et Anatomia, Parmæ, 1791–93, 2 vols. fol. fig., continued by Delle Chiaje.

[2] OWEN, (R.,) Memoir on the Pearly Nautilus, London, 1832, 4to. fig. — VALENCIENNES, (A.,) Nouvelles Recherches anatomiques sur le Nautile. C. R., Paris, 1841, 4to. — CUVIER, (G.,) Mémoires pour servir à l'Histoire et à l'Anatomie des Mollusques, Paris, 1817, 4to. fig. — EDWARDS, (H. M.,) QUATREFAGES, (AR. DE,) et BLANCHARD, (EM.) Voyage en Sicile, Paris, 3 vols. 4to. fig. (without date.)

but the Crustacea exhibit, again, the most striking coincidence. Without entering into details, it appears from the classification of Milne-Edwards that Decapods, Stomapods, Amphipods, and Isopods constitute the higher orders, while Branchiopods, Entomostraca, Trilobites, and the parasitic types, constitute, with Limulus, the lower orders of this class.[1] In the classification of Dana,[2] his first type embraces Decapods and Stomapods, the second Amphipods and Isopods, the third Entomostraca, including Branchiopods, the fourth Cirripedia, and the fifth Rotatoria. Both acknowledge in the main the same gradation; though they differ greatly in the combination of the leading groups, and also the exclusion by Milne-Edwards of some types, as the Rotifera, which Burmeister first, then Dana and Leydig, unite justly, as I believe, with the Crustacea.[3] This gradation now presents the most perfect coincidence with the order of succession of Crustacea in past geological ages, even down to their subdivisions into minor groups. Trilobites and Entomostraca are the only representatives of the class in palæozoic rocks; in the middle geological ages appear a variety of Shrimb, among which the Macrouran Decapods are prominent, and later only the Brachyoura, which are the most numerous in our days.

The fragmentary knowledge we possess of the fossil Insects, does not justify us, yet, in expecting to ascertain with any degree of precision, the character of their succession through all geological formations, though much valuable information has already been obtained respecting the entomological faunæ of several geological periods.[4]

The order of succession of Vertebrata in past ages, exhibits features in many respects differing greatly from the Articulata, Mollusks, and Radiata. Among these we find their respective classes appearing simultaneously in the oldest periods of the history of our earth. Not so with the Vertebrata, for though Fishes may be as old as any of the lower classes, Reptiles, Birds, and Mammalia are introduced successively in the order of their relative rank in their type. Again, the earliest representatives of these classes do not always seem to be the lowest; on the contrary, they are to a certain extent, and in a certain sense, the highest, in as far as they embody characters, which, in later periods, appear separately in higher classes, (See Sect. 26,) to the exclusion of what henceforth constitutes the special character of the lower class. For instance, the oldest Fishes known partake of the characters, which, at a later time, are exclusively found in Reptiles, and no longer belong to the Fishes of the present day. It may be said, that the earliest Fishes are rather the oldest representatives of the type of Vertebrata than of the

[1] MILNE-EDWARDS, Hist. Nat. des Crustacés, Paris, 1834–40, 3 vols. 8vo.

[2] DANA, (J. D.,) Crustacea, q. a., p. 32.

[3] LEYDIG, (FR.,) Räderthiere, etc., Zeitsch. f. wiss. Zool. 1854, vol. 6, p. 1.

[4] HEER, q. a.; BRODIE, q. a., p. 98.

class of Fishes, and that this class assumes only its proper characters after the introduction of the class of Reptiles upon earth. Similar relations may be traced between the Reptiles and the classes of Birds and Mammalia, which they precede. I need only allude here to the resemblance of the Pterodactyli and the Birds, and to that of Ichthyosauri and certain Cetacea. Yet, through all these intricate relations, there runs an evident tendency towards the production of higher and higher types, until at last, Man crowns the whole series. Seen as it were at a distance, so that the mind can take a general survey of the whole, and perceive the connection of the successive steps, without being bewildered by the details, such a series appears like the development of a great conception, expressed in such harmonious proportions, that every link appears necessary to the full comprehension of its meaning, and yet, so independent and perfect in itself, that it might be mistaken for a complete whole, and again, so intimately connected with the preceding and following members of the series, that one might be viewed as flowing out of the other. What is universally acknowledged as characteristic of the highest conceptions of genius, is here displayed in a fulness, a richness, a magnificence, an amplitude, a perfection of details, a complication of relations, which baffle our skill and our most persevering efforts to appreciate all its beauties. Who can look upon such series, coinciding to such an extent, and not read in them the successive manifestations of a thought, expressed at different times, in ever new forms, and yet tending to the same end, onwards to the coming of Man, whose advent is already prophesied in the first appearance of the earliest Fishes!

The relative standing of plants presents a somewhat different character from that of animals. Their great types are not built upon so strictly different plans of structure; they exhibit, therefore, a more uniform gradation from their lowest to their highest types, which are not personified in one highest plant, as the highest animals are in Man.

Again, Zoölogy is more advanced respecting the limitation of the most comprehensive general divisions, than Botany, while Botany is in advance respecting the limitation and characteristics of families and genera. There is, on that account, more diversity of opinion among botanists respecting the number, and the relative rank of the primary divisions of the vegetable kingdom, than among zoölogists respecting the great branches of the animal kingdom. While most writers[1] agree in admitting among plants, such primary groups as Acotyledones, Monocotyledones, and Dicotyledones, under these or other names, others would separate the Gymnosperms from the Dicotyledones.[2]

It appears to me, that this point in the classification of the living plants cannot

[1] Göppert, etc., q. a., p. 93.

[2] Ad. Brongniart, etc., q. a., p. 93.

be fully understood without a thorough acquaintance with the fossils and their distribution in the successive geological formations, and that this case exhibits one of the most striking examples of the influence classification may have upon our appreciation of the gradation of organized beings in the course of time. As long as Gymnosperms stand among Dicotyledones, no relation can be traced between the relative standing of living plants and the order of succession of their representatives in past ages. On the contrary, let the true affinity of Gymnosperms with Ferns, Equisetaceæ, and especially with Lycopodiaceæ be fully appreciated, and at once we see how the vegetable kingdom has been successively introduced upon earth, in an order which coincides with the relative position its primary divisions bear to one another, in respect to their rank, as determined by the complication of their structure. Truly, the Gymnosperms, with their imperfect flower, their open carpels, supporting their polyembryonic seeds in their axis, are more nearly allied to the anathic Acrophytes, with their innumerable spores, than to either the Monocotyledones or Dicotyledones; and, if the vegetable kingdom constitutes a graduated series beginning with Cryptoganes, followed by Gymnosperms, and ending with Monocotyledones and Dicotyledones, have we not in that series the most striking coincidence with the order of succession of Cryptogams in the oldest geological formations, especially with the Ferns, Equisetaceæ, and Lycopodiaceæ of the Carboniferous period, followed by the Gymnosperms of the Trias and Jura and the Monocotyledones of the same formation and the late development of Dicotyledones? Here, as everywhere, there is but one order, one plan in nature.

SECTION XXV.

PARALLELISM BETWEEN THE GEOLOGICAL SUCCESSION OF ANIMALS AND THE EMBRYONIC GROWTH OF THEIR LIVING REPRESENTATIVES.

Several authors have already alluded to the resemblance which exists between the young of some of the animals now living, and the fossil representatives of the same families in earlier periods.[1] But these comparisons have, thus far, been traced only in isolated cases, and have not yet led to a conviction, that the character of the succession of organized beings in past ages, is such, in general, as to show

[1] AGASSIZ, (L.,) Poiss. foss., q. a., p. 54. — Embryonic Types, q. a., p. 11. — Twelve Lect., etc., p. 8. — EDWARDS, (H. MILNE,) Considérations sur quelques principes relatifs à la Classification naturelle des animaux, An. Sc. Nat., 3e sér., 1844, 1 vol. p. 65.

a remarkable agreement with the embryonic growth of animals; though the state of our knowledge in Embryology and Palæontology justifies now such a conclusion. The facts most important to a proper appreciation of this point, have already been considered in the preceding paragraph, as far as they relate to the order of succession of animals, when compared with the relative rank of their living representatives. In examining now the agreement between this succession and the phases of the embryonic growth of living animals, we may, therefore, take for granted, that the order of succession of their fossil representatives is sufficiently present to the mind of the reader, to afford a satisfactory basis of comparison. Too few Corals have been studied embryologically, to afford extensive means of comparison; yet so much is known, that the young polyp, when hatched, is an independent, simple animal, that it is afterwards incased in a cup, secreted by the foot of the actinoid embryo, which may be compared to the external wall of the *Rugosa*,[1] and that the polyp gradually widens until it has reached its maximum diameter, prior to budding or dividing, while in ancient corals this stage of enlargement seems to last during their whole life, as, for example, in the Cyathophylloids. None of the ancient Corals form those large communities, composed of myriads of united individuals, so characteristic of our coral reefs; the more isolated and more independent character of the individual polyps of past ages presents a striking resemblance to the isolation of young corals, in all the living types. In no class is there, however, so much to learn still, as in Polypi, before the correspondence of their embryonic growth, and their succession in time, can be fully appreciated. In this connection I would also remark, that among the lower animals, it is rarely observed, that any one, even the highest type, represents in its metamorphoses all the stages of the lower types, neither in their development, nor in the order of their succession; and that frequently the knowledge of the embryology of several types of different standing, is required, to ascertain the connection of the whole series in both spheres.

No class affords, as yet, a more complete and more beautiful evidence of the correspondence of their embryonic changes, with the successive appearance of their representatives in past ages, than the Echinoderms, thanks to the extensive and patient investigations of J. Müller upon the metamorphoses of these animals.[2] Prior to the publication of his papers, the metamorphosis of the European Comatula alone was known. (See Sect. XVIII., p. 85.) This had already shown, that the early stages of growth of this Echinoderm exemplify the peduncated Crinoids of past ages. I have myself seen further, that the successive stages of the embryonic growth of Comatula typify, as it were, the principal forms of Crinoids which characterize the successive

[1] Milne-Edwards et Haime, q. a., p. 31.

[2] Müller, (J.,) Seven papers, q. a., p. 71.

geological formations; first, it recalls the Cistoids of the palæozoic rocks, which are represented in its simple sphæroidal head, next the few-plated Platycrinoids of the Carboniferous period, next the Pentacrinoids of the Lias and Oolithe, with their whorls of cirrhi, and finally, when freed from its stem, it stands as the highest Crinoid, as the prominent type of the family, in the present period. The investigations of Müller upon the larvæ of all the families of living Asterioids and Echinoids enable us to extend these comparisons to the higher Echinoderms also. The first point which strikes the observers in the facts ascertained by Müller, is the extraordinary similarity of so many larvæ, of such different orders and different families as the Ophiuroids and Asterioids, the Echinoids proper and the Spatangoids, and even the Holothurioids, all of which end, of course, in reproducing their typical peculiarities. It is next very remarkable, that the more advanced larval state of Echinoids and Spatangoids should continue to show such great similarity, that a young Amphidetus hardly differs from a young Echinus.[1] Finally, not to extend these remarks too far, I would only add, that these young Echinoids (Spatangus, as well as Echinus proper) have rather a general resemblance to Cidaris, on account of their large spines, than to Echinus proper. Now, these facts agree exactly with what is known of the successive appearance of Echinoids in past ages;[2] their earliest representatives belong to the genera Diadema and Cidaris, next come true Echinoids, later only Spatangoids. When the embryology of the Clypeastroids is known, it will, no doubt, afford other links to connect a larger number of the members of this series.

What is known of the embryology of Acephala, Gasteropoda, and Cephalopoda, affords but a few data for such comparisons. It is, nevertheless, worthy of remark, that while the young *Lamellibranchiata* are still in their embryonic stage of growth, they resemble, externally at least, Brachiopods[3] more than their own parents, and the young shells of all Gasteropods[4] known in their embryonic stage of growth, being all holostomate, recall the oldest types of that class. Unfortunately, nothing is yet known of the embryology of the Chambered Cephalopoda, which are the only ones found in the older geological formations, and the changes which the shield of the Dibranchiata undergoes have not yet been observed, so that no comparisons can be established between them and the Belemnites and other representatives of this order in the middle and more recent geological ages.

Respecting Worms, our knowledge of the fossils is too fragmentary to lead to any conclusion, even should our information of the embryology of these animals

[1] Compare J. Müller's 1st paper, pl. III., with pls. IV.–VII., and with pls. VI. and VII., 4th paper.

[2] AGASSIZ, (L.,) Twelve Lectures, q. a., etc. p. 25.

[3] See the works, q. a., p. 73, note 1.

[4] See the works, q. a., p. 73, note 2, especially those relating to Nudibranchiata.

be sufficient as a basis for similar comparisons. The class of Crustacea, on the contrary, is very instructive in this respect; but, to trace our comparisons through the whole series, it is necessary that we should consider simultaneously the embryonic growth of the higher Entomostraca, such as Limulus, and that of the highest order of the class,[1] when it will appear, that as the former recall in early life the form and character of the Trilobites, so does the young Crab passing through the form of the Isopods, and that of the Macrouran Decapods, before it assumes its typical form as Brachyouran, recall the well-known succession of Crustacea through the geological middle ages and the tertiary periods to the present day. The early appearance of Scorpions, in the Carboniferous period, is probably also a fact to the point, if, as I have attempted to show, Arachnidians may be considered as exemplifying the chrysalis stage of development of Insects;[2] but, for reasons already stated (Sect. XXIV.) it is hardly possible to take Insects into consideration in these inquiries.

In my researches upon fossil Fishes,[3] I have pointed out at length the embryonic character of the oldest fishes, but much remains to be done in that direction. The only fact of importance I have learned of late, is that the young Lepidosteus, long after it has been hatched, exhibits in the form of its tail, characters, thus far only known among the fossil fishes of the Devonian system.[4] It is to be hoped, that the embryology of the Crocodile will throw some light upon the succession of the gigantic Reptiles of the middle geological ages, as I shall show, that the embryology of Turtles throws light upon the fossil Chelonians. It is already plain, that the embryonic changes of Batrachians coincide with what is known of their succession in past ages.[5] The fossil Birds are too little known, and the fossil Mammalia[6] do not extend through a sufficiently long series of geological formations to afford many striking points of comparison; yet, the characteristic peculiarities of their extinct genera exhibit everywhere indications, that their living representatives in early life resemble them more than they do their own parents. A minute comparison of a young elephant, with any mastodon, will show this most fully, not only in the peculiarities of their teeth, but even in the proportion of their limbs, their toes, etc.

It may, therefore, be considered as a general fact, very likely to be more fully illustrated as investigations cover a wider ground, that the phases of development of all living animals correspond to the order of succession of their extinct representatives in past geological times. As far as this goes, the oldest representatives

[1] AGASSIZ, (L.,) Twelve Lectures, etc., p. 66.
[2] Classif. of Insects, q. a., p. 85.
[3] Poiss. fossiles, q. a., p. 54.
[4] AGASSIZ, (L.,) Lake Superior, etc., p. 254.
[5] See the works, q. a., p. 82, note 3.
[6] CUV., Oss. foss., q. a.: also, AGASSIZ, (L.,) Zoölogical Character of Young Mammalia, Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 85.

of every class may then be considered as embryonic types of their respective orders or families among the living. Pedunculated Crinoids are embryonic types of the Comatuloids, the oldest Echinoids embryonic representatives of the higher living families, Trilobites embryonic types of Entomostraca, the Oolitic Decapods embryonic types of our Crabs, the Heterocercal Ganoids embryonic types of the Lepidosteus, the Andrias Scheuchzeri an embryonic prototype of our Batrachians, the Zeuglodonts embryonic Sirenidæ, the Mastodonts embryonic Elephants, etc.

To appreciate, however, fully and correctly all these relations, it is further necessary to make a distinction between embryonic types in general, which represent in their whole organization early stages of growth of higher representatives of the same type, and *embryonic features* prevailing more or less extensively in the characters of allied genera, as in the case of the Mastodon and Elephant, and what I would call *hypembryonic types*, in which embryonic features are developed to extremes in the further periods of growth, as, for instance, the wings of the Bats, which exhibit the embryonic character of a webbed hand, as all Mammalia have it at first, but here grown out and developed into an organ of flight, or assuming in other families the shape of a fin, as in the Whale, or the Sea-turtle, in which the close connection of the fingers is carried out to another extreme.

Without entering into further details upon this subject, which will be fully illustrated in this work, enough has already been said to show, that the leading thought which runs through the succession of all organized beings in past ages, is manifested again in new combinations, in the phases of the development of the living representatives of these different types. It exhibits everywhere the working of the same creative Mind, through all times, and upon the whole surface of the globe.

SECTION XXVI.

PROPHETIC TYPES AMONG ANIMALS.

We have seen in the preceding paragraph, how the embryonic conditions of higher representatives of certain types, called into existence at a later time, are typified, as it were, in representatives of the same types, which have existed at an earlier period. These relations, now they are satisfactorily known, may also be considered as exemplifying, as it were, in the diversity of animals of an earlier period, the pattern upon which the phases of the development of other animals

of a later period were to be established. They appear now, like a prophecy in those earlier times, of an order of things not possible with the earlier combinations then prevailing in the animal kingdom, but exhibiting in a later period, in a striking manner, the antecedent considerations of every step in the gradation of animals.

This is, however, by no means the only, nor even the most remarkable case, of such prophetic connections between facts of different dates.

Recent investigations in Palæontology have led to the discovery of relations between animals of past ages and those now living, which were not even suspected by the founders of that science. It has, for instance, been noticed, that certain types which are frequently prominent among the representatives of past ages, combine in their structure, peculiarities which at later periods are only observed separately in different, distinct types. Sauriod Fishes before Reptiles, Pterodactyles before Birds, Ichthyosauri before Dolphins, etc.

There are entire families, among the representatives of older periods, of nearly every class of animals, which, in the state of their perfect development exemplify such prophetic relations, and afford, within the limits of the animal kingdom, at least, the most unexpected evidence, that the plan of the whole creation had been maturely considered long before it was executed. Such types, I have for some time past, been in the habit of calling *prophetic types*. The Sauroid[1] Fishes of the past geological ages, are an example of this kind. These Fishes, which have preceded the appearance of Reptiles, present a combination of ichthyic and reptilian characters, not to be found in the true members of this class, which form its bulk at present. The Pterodactyles[2] which have preceded the class of Birds, and the Ichthyosauri[3] which have preceded the appearance of the Crustacea, are other examples of such prophetic types. These cases suffice for the present, to show that there is a real difference between *embryonic* types and *prophetic* types. Embryonic types are in a measure also prophetic types, but they exemplify only the peculiarities of development of the higher representatives of their own types; while prophetic types exemplify structural combinations observed at a later period, in two or several distinct types, and are, moreover, not necessarily embryonic in their character, as for example, the Monkeys in comparison to Man; while they may be so, as in the case of the Pinnate, Plantigrade, and Digitigrade Carnivora, or still more so in the case of the pedunculated Crinoids.[4]

Another combination is also frequently observed among animals, when a series exhibits such a succession as exemplifies a natural gradation, without immediate

[1] AGASSIZ, (L.,) Poiss. foss., vol. 2, part 2.
[2] CUVIER, (G.,) Oss. foss., vol. 5, p. 2.
[3] CUVIER, (G.,) Oss. foss., as q. a.
[4] See above, Sect. 25.

or necessary reference to either embryonic development or succession in time, as the Chambered Cephalopods. Such types I call *progressive types*.[1]

Again, a distinction ought to be made between prophetic types proper and what I would call *synthetic types*, though both are more or less blended in nature. Prophetic types proper, are those which in their structural complications lean towards other combinations fully realized in a later period, while synthetic types, are those which combine, in a well balanced measure, features of several types occurring as distinct, only at a later time. Sauroid Fishes and Ichthyosauri are more distinctly synthetic than prophetic types, while Pterodactyles have more the character of prophetic types; so are also Echinocrinus with reference to Echini, Pentremites with reference to Asterioids, and Pentacrinus with reference to Comatula. Full illustrations of these different cases will yet be needed to render obvious the importance of such comparisons, and I shall not fail, in the course of this work, to present ample details upon this subject. Enough, however, has already been said to show, that the character of these relations among animals of past ages, compared with those of later periods or of the present day, exhibits more strikingly than any other feature of the animal kingdom, the thoughtful connection which unites all living beings, through all ages, into one great system, intimately linked together from beginning to end.

SECTION XXVII.

PARALLELISM BETWEEN THE STRUCTURAL GRADATION OF ANIMALS AND THEIR EMBRYONIC GROWTH.

So striking is the resemblance of the young of higher animals to the full-grown individuals of lower types, that it has been assumed by many writers that all the higher animals pass, during the earlier stages of their growth, through phases corresponding to the permanent constitution of the lower classes. These suppositions, the results of incomplete investigations, have even become the foundation of a system of philosophy of Nature, which represents all animals as the different degrees of development of a few primitive types.[2] These views have been too generally circulated of late, in an anonymous work, entitled "Vestiges of Creation," to require

[1] AGASSIZ, (L.,) On the Difference between Progressive, Embryonic, and Prophetic Types, etc., Proc. Am. Ass. Adv. Sc., Cambridge, 1849, p. 432.

[2] LAMARCK, q. a., p. 26. — DUMAILLET, (Pseudon. TELLIAMED,) Entretiens d'un Philosophe indien avec un missionaire français, Amsterdam, 1748, 2 vols. 8vo. — OKEN, (LOR.,) Lehrbuch der Natur-Philosophie, q. a., p. 18. — The Vestiges of Creation, etc.

further mention here. It has also been shown above (Sect. VIII.) that animals do not form such a simple series as would result from a successive development. There remains, therefore, only for us to show now within what limits the natural gradation which may be traced in the different types of the animal kingdom,[1] corresponds to the changes they undergo during their growth, having already considered the relations which exist between these metamorphoses and the successive appearance of animals upon earth, and between the latter and the structural gradation or relative standing of their living representatives. Our knowledge of the complication of structure of all animals is sufficiently advanced to enable us to select, almost at random, our examples of the correspondence between the structural gradation of animals and their embryonic growth, in all those classes the embryologic development of which has been sufficiently investigated. Yet, in order to show more distinctly how closely all the leading features of the animal kingdom are combined, whether we consider the complication of their structure, or their succession in time, or their embryonic development, I shall refer by preference to the same types which I have chosen before for the illustration of the other relations.

Among Echinoderms, we find in the order of Crinoids the pedunculated types standing lowest,[2] Comatulæ highest, and it is well known that the young Comatula is a pedunculated Crinoid, which only becomes free in later life.[3] J. Müller has shown that among the Echinoids, even the highest representatives, the Spatangoids, differ but slightly in early youth from the Echinoids, and no zoölogist can doubt that these are inferior to the former. Among Crustacea, Dana[4] has insisted particularly upon the serial gradation which may be traced between the different types of Decapods, their order being naturally from the highest Bruchyoura, through the Anomoura, the Macroura, the Tetradecapods, etc., to the Entomostraca; the Macrouran character of the embryo of our Crabs has been fully illustrated by Rathke,[5] in his beautiful investigations upon the embryology of Crustacea. I have further shown that the young of Macroura represents even Entomostraca forms, some of these young having been described as representatives of that order.[6] The correspondence between the gradation of Insects and their embryonic growth, I have illustrated fully in a special paper.[7] Similar comparisons have been made in the class of Fishes;[8] among Reptiles, we find the most striking examples

[1] See the works quoted from p. 67–87, also MILNE-EDWARDS, q. a., p. 112. — THOMPSON, Crinoids, q. a.

[2] MÜLLER, (J.,) Ueber Pentacrinus Caput-Medusæ, Berlin, 1833, 4to., Ak. d. Wiss.

[3] FORBES, (ED.,) History of British Starfishes, London, 1851, 1 vol. 8vo., p. 10.

[4] DANA, q. a., p. 32. — BURMEISTER, Cirripeds, q. a., p. 79. — THOMPSON, q. a., p. 79.

[5] RATHKE, q. a., p. 79.

[6] Twelve Lectures, etc., p. 67.

[7] Classification of Insects, q. a.

[8] Poissons fossiles, q. a.

of this kind among Batrachians[1] (see, above, Sect. XII.); among Birds,[2] the uniformly webbed foot, in all young, exhibits another correspondence between the young of higher orders and the permanent character of the lower ones. In the order of Carnivora, the Seals, the Plantigrades, and the Digitigrades exemplify the same coincidence between higher and higher representatives of the same types, and the embryonic changes through which the highest pass successively.

No more complete evidence can be needed to show that there exists throughout the animal kingdom the closest correspondence between the gradation of their types and the embryonic changes their respective representatives exhibit throughout. And yet what genetic relation can there exist between the Pentacrinus of the West Indies and the Comatulæ, found in every sea; what between the embryos of Spatangoids and those of Echinoids, and between the former and the adult Echinus; what between the larva of a Crab and our Lobsters; what between the Caterpillar of a Papilio and an adult Tinea, or an adult Sphinx; what between the Tadpole of a Toad and our Menobranchus; what between a young Dog and our Seals, unless it be the plan designed by an intelligent Creator?

SECTION XXVIII.

RELATIONS BETWEEN THE STRUCTURE, EMBRYONIC GROWTH, GEOLOGICAL SUCCESSION, AND THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

It requires unusual comprehensiveness of view to perceive the order prevailing in the geographical distribution of animals. We should, therefore, not wonder that this branch of Zoölogy is so far behind the other divisions of that science. Nor should we wonder at the fact that the geographical distribution of plants is so much better known than that of animals, when we consider how marked a feature the vegetable carpet which covers the surface of our globe is, when compared with the little show animals make, almost everywhere. And yet it will, perhaps, some day, be easier to understand the relations existing between the geographical distribution of animals and the other general relations prevailing among animals, because the range of structural differences is much greater among animals than among plants. Even now, some curious coincidences may be pointed out which go far to show that the geographical distribution of animals stands in direct relation to their rela-

[1] Twelve Lectures, etc., p. 8.

[2] AGASSIZ, (L.,) Lake Superior, etc., p. 194.

tive standing in their respective classes, and to the order of their succession in past geological ages, and more indirectly, also, to their embryonic growth.

Almost every class has its tropical families, and these stand generally highest in their respective classes; or, when the contrary is the case, when they stand evidently upon a lower level, there is some prominent relation between them and the prevailing types of past ages. The class of Mammalia affords striking examples of these two kinds of connection. In the first place, the Quadrumana, which, next to Man, stand highest in their class, are all tropical animals; and it is worthy of remark, that the two highest types of Anthropoid Monkeys, the Orangs of Asia and the Chimpanzees of Western Africa bear, in the coloration of their skin, an additional similarity to the races of Man inhabiting the same regions, the Orangs being yellowish red, as the Malays, and the Chimpanzee blackish, as the Negroes. The Pachyderms, on the contrary, stand low in their class, though chiefly tropical; but they constitute a group of animals prominent among the earliest representatives of that class in past ages. Among Chiroptera, the larger frugivorous representatives are essentially tropical; the more omnivorous, on the contrary, occur everywhere. Among Carnivora, the largest, most powerful, and also highest types, the Digitigrade, prevail in the tropics, while among the Plantigrades, the most powerful, the Bears, belong to the temperate and to the arctic zone, and the lowest, the Pinnate, are marine species of the temperate and arctic seas. Among Ruminants, we find the Giraffe and the Camels in the warmer zones, the others everywhere. In the class of Birds the gradation is not so obvious as in other classes, and yet the aquatic types form by far the largest representation of this class in temperate and cold regions, and are almost the only ones found in the arctic, while the higher land birds prevail in the warm regions. Among Reptiles, the Crocodilians are entirely tropical; the largest land Turtles are also only found in the tropics, and the aquatic representatives of this order, which are evidently inferior to their land kindred, extend much further north. The Rattlesnakes and Vipers extend further north and higher up the mountains than the Boas and the common harmless snakes. The same is true of Salamanders and Tritons. The Sharks and Skates are most diversified in the tropics. It is also within the tropics that the most brilliant diurnal Lepidoptera are found, and this is the highest order of Insects. Among Crustacea the highest order, the Brachyoura, are most numerous in the torrid zone; but Dana has shown, what was not at all expected, that they nevertheless reach their highest perfection in the middle temperate regions.[1] The Anomoura and Macroura, on the contrary, are nearly equally divided between the torrid and temperate zones; while the lower Tetradecapods are far more numerous in extra tropical latitudes than in the tropical. The

[1] DANA, Crustacea, p. 1501.

Cephalopods are most diversified within the tropics; yet the Nautilus is a reminiscence of past ages. Among Gasteropods, the Stromboids belong to the tropics; but among the lamellibranchiate Acephala, the Naiades, which seem to me to stand very high in their class, have their greatest development in the fresh waters of North America. The highest Echinoderms, the Holothurians and Spatangoids are most diversified within the tropics, while Echini, Starfishes, and Ophiuræ extend to the arctics. The presence of Pentacrinus in the West Indies has undoubtedly reference to the prevalence of Crinoids in past ages. The Madrepores, the highest among the Actinoid Polypi, are entirely tropical, while the highest Halcyonoids, the Renilla, Veretillum, and Pennatula, extend to the tropics and the temperate zone.

Another interesting relation between the geographical distribution of animals and their representatives in past ages, is the absence of embryonic types in the warm regions. We find in the torrid zone no true representatives of the oldest geological periods; Pentacrinus is not found before the Lias; among Cephalopods we find the Nautilus, but nothing like Orthoceras; Limulus, but nothing like Trilobites.

This study of the relations between the geographical distribution of animals, and their relative standing, is rendered more difficult, and in many respects obscure, by the circumstance that entire types, characterized by peculiar structures, are so strangely limited in their range; and yet, even this shows how closely the geographical distribution of animals is connected with their structure. Why New Holland should have no Monkeys, no Carnivora, no Ruminants, no Pachyderms, no Edentata, is not to be explained; but that this is the case, every zoölogist knows, and is further aware, that the Marsupials[1] of that continental island represent, as it were, the other orders of Mammalia, under their special structural modifications. New Holland appears thus as a continent with the characters of an older geological age. No one can fail, therefore, to perceive of how great an interest for Classification will be a more extensive knowledge of the geographical distribution of animals in general, and of the structural peculiarities exhibited by localized types.

SECTION XXIX.

MUTUAL DEPENDENCE OF THE ANIMAL AND VEGETABLE KINGDOMS.

Though it had long been known, by the experiments of De Saussure, that the breathing process of animals and plants are very different, and that while the for-

[1] See Sect. 11.

mer inhale atmospheric air, and exhale carbonic acid gas, the latter appropriate carbon and exhale oxygen, it was not until Dumas and Bousingault[1] called particularly the attention of naturalists to the subject, that it was fully understood how direct the dependence is of the animal and vegetable kingdoms one upon the other, in that respect, or rather how the one consumes what the other produces, and *vice versâ*, thus tending to keep the balance which either of them would singly disturb to a certain degree. The common agricultural practice of manuring exhibits from another side the dependence of one kingdom upon the other: the undigested particles of the food of animals return to the ground, to fertilize it for fresh production.[2] Again, the whole animal kingdom is either directly or indirectly dependent upon the vegetable kingdom for its sustenance, as the herbivorous animals afford the needful food for the carnivorous tribes. We are too far from the time when it could be supposed that Worms originated in the decay of fruits and other vegetable substances, to need here repetition of what is known respecting the reproduction of these animals. Nor can it be necessary to show how preposterous the assumption would be that physical agents produced plants first, in order that from these, animals might spring forth. Who could have taught the physical agents to make the whole animal world dependent upon the vegetable kingdom?

On the contrary, such general facts as those above alluded to, show, more directly than any amount of special disconnected facts could do, the establishment of a well-regulated order of things, considered in advance; for they exhibit well-balanced conditions of existence, prepared long beforehand, such as only an intelligent being could ordain.

SECTION XXX.

PARASITIC ANIMALS AND PLANTS.

However independent of each other some animals may appear, there are yet many which live only in the closest connection with their fellow-creatures, and which are known only as parasites upon or within them. Such are the intestinal Worms, and all the vermin of the skin.[3] Among plants, the Mistletoe, Orobanche,

[1] DUMAS, Leçon sur la statique chimique des êtres organisés, Ann. Sc. Nat. 2de sér. vol. 6, p. 33; vol. 17, p. 122.

[2] LIEBIG, Agricultural Chemistry; Animal Chemistry.

[3] See above, p. 76, notes 1 and 2, and p. 77, notes 1 and 2; see also RUDOLPHI, (K. A.,) Entozoorum sive Vermium, etc., q. a., p. 31. — BREMSER, (J. G.,) Ueber lebende Würmer im lebenden Menschen, Wien, 1819, 4to. — DUJARDIN, (F.,) Hist. Nat. des Helminthes, etc., q. a., p. 32. — DIESING, (C. M.,) Historia Vermium, etc., q. a., p. 32.

Rafflesia, and many Orchideæ may be quoted as equally remarkable examples of parasitism.

There exists the greatest variety of parasites among animals. It would take volumes to describe them and to write their history, for their relations to the animals and plants upon which they are dependent for their existence are quite as diversified as their form and their structure.

It is important, however, to remark, at the outset, that these parasites do not constitute for themselves one great division of the animal kingdom. They belong, on the contrary, to all its branches; almost every class has its parasites, and in none do they represent one natural order. This fact is very significant, as it shows at once that parasitism is not based upon peculiar combinations of the leading structural features of the animal kingdom, but upon correlations of a more specific character. Nor is the degree of dependence of parasites upon other organized beings equally close. There are those which only dwell upon other animals, while others are so closely connected with them that they cannot subsist for any length of time out of the most intimate relation to the species in which they grow and multiply. Nor do these parasites live upon one class of animals; on the contrary, they are found in all of them.

Among Vertebrata there are few parasites, properly speaking. None among Mammalia. Among Birds, a few species depend upon others to sit upon their eggs and hatch them, as the European Cuckoo, and the North American Cowbird. Among Fishes, some small Ophidiums (Fierasfers) penetrate into the cavity of the body of large Holothuriæ in which they dwell.[1] Echeneis attach themselves to other fishes, but only temporarily. Among Articulata, the number of parasites is largest. It seems to lie in the very character of this type, so remarkable for the outward display of their whole organization, to include the greatest variety of parasites. And it is really among them, that we observe the most extraordinary combinations of this singular mode of existence.

Insects, in general, are more particularly dependent upon plants for their sustenance than herbivorous animals usually are, inasmuch as most of them are limited to particular plants for their whole life, such as the Plant-lice, the Coccus, the Gall Insects. In others, the larvæ only are so limited to particular plants, while the larvæ of others still, such as the Bots, grow and undergo their development under the skin or in the intestines, or in the nasal cavities of other animals. The Ichneumons lay their eggs in the larvæ of other insects, upon which the young larvæ prey until hatched. Among perfect Insects, there are those which live only in community with others, such as the Ant-Hill Insects, the Clavigers, the Clerus,

[1] See above, p. 74, note.

and Bees. Different kinds of Ants live together, if not as parasites one upon another, at least in a kind of servitude. Other Insects live upon the bodies of warm blooded animals, such as the Fleas and Lice, and of these the number is legion. Some Hydrachnas are parasitic upon aquatic Mollusks.[1]

Among Crustacea, there are Crabs constantly living in the shell of Mollusks, such as the Pinnotheres of the Oyster and Mussel. I have found other species upon Sea-Urchins, (Pinnotheres Melittæ, a new species, upon Melitta quinquefora). The Paguri take the shells of Mollusks to protect themselves; while a vast number of Amphipods live upon Fishes, attached to their gills, upon their tongue, or upon their skin, or upon Starfishes.[2] The Cyamus Ceti lives upon the Whale. Some Cirripeds are parasites upon the Whales, others upon Corals. In the family of Lernæans, the females are mostly parasites upon the gills or fins or upon the body of Fishes, while the males are free.

Among Worms this mode of existence is still more frequent, and while some dwell only among Corals, entire families of others consist only of genuine parasites; but here again we find the most diversified relations; for, while some are constantly parasitic, others depend only for a certain period of their life upon other animals for their existence. The young Gordius is a free animal; it then creeps into the body of Insects, and leaves them again to propagate; the young Distoma lives free in the water as Cercaria, and spends the remainder of its life in other animals; the Tænia, on the contrary, is a parasite through life, and only its eggs pass from one animal into the other. But what is most extraordinary in this, as in many other intestinal Worms, is the fact, that while they undergo their first transformations in some kind of animals, they do not reach their complete development until they pass into the body of another higher type, being swallowed up by this while in the body of their first host. Such is the case with many Filariæ, the Tæniæ and Bothrocephali. These at first inhabit lower Fishes, and these Fishes being swallowed by Sharks or Water Birds, or Mice with their Worms being eaten up by Cats, the parasites living in them undergo their final transformation in the latter. Many Worms undertake extensive migrations through the bodies of other animals, before they reach the proper place for their final development.[3]

[1] NITZSCH, (CHR. L.,) Darstellung der Familien und Gattungen der Thierinsekten, Halle, 1818, 8vo. — HAYDEN, (C. v.,) Versuch einer systematischen Eintheilung der Acariden, Isis, 1826, p. 608. — RATZENBURG, (J. S. C.,) Die Ichneumonen der Forstinsekten, Berlin, 1844–52, 3 vols. 4to. fig. — CLARK, (BR.,) Observations on the Genus Oestrus, Trans. Lin. Soc., III., p. 289, fig. — KOCH, (C. L.,) Die Pflanzen-Läuse, Aphiden, Nürnberg, 1846, 8vo. fig. — DUGÈS, (ANT.,) Recherches sur l'ordre des Acariens, Ann. Sc. Nat., 2de sér., 1834, I., p. 5, II., p. 18, fig.

[2] I have found a new genus of this family upon Asterias Helianthoides.

[3] See above, p. 76, note 1; SIEBOLD, Wanderung, etc., p. 77, note 1; STEENSTRUP, etc.

Among Mollusks, parasites are very few, if any can properly be called true parasites, as the males of some Cephalopods living upon their own females;[1] as the Gasteropods growing buried in Corals,[2] and the Lithodomus and a variety of Arcas found in Corals. Among Radiata there are no parasites, properly speaking; some of them only attaching themselves by preference to certain plants, while the young of others remain connected with their parent, as in all Corals, and even among Crinoids, as in the Comatula of Charleston.

In all these different cases, the chances that physical agents may have a share in producing such animals are still less than in the cases of independent animals, for here we have superadded to the very existence of these beings all the complicated circumstances of their peculiar mode of existence and their various connections with other animals. Now, if it can already be shown from the mere connections of independent animals, that external circumstances cannot be the cause of their existence, how much less could such an origin be ascribed to parasites! It is true, they have been supposed to originate in the body of the animals upon which they live. What then of those who enter the body of other animals at a somewhat advanced stage of growth, as the Gordius? Is it a freak of his? Or, what of those which only live upon other animals, such as lice; are they the product of the skin? Or, what of those which have to pass from the body of a lower into that of a higher animal, to undergo their final metamorphosis and in which this succession is normal? Was such an arrangement devised by the first animal, or imposed upon the first by the second, or devised by physical agents for the two? Or, what of those in which the females only are parasites? Had the two sexes a different origin? Did perhaps the males and females originate in different ways?

I am at a loss to conceive how the origin of parasites can be ascribed to physical causes, unless, indeed, animals themselves be considered as physical causes, with reference to the parasites they nourish; and if so, why can they not get rid of them, as well as produce them, for it cannot be supposed, that all this is not done consciously, when parasites bear such close structural relations to the various types to which they belong?

The existence of parasitic animals belonging to so many different types of the animal as well as the vegetable kingdom, is a fact of deep meaning, which Man himself cannot too earnestly consider, and, while he may marvel at the fact, take it as a warning for himself, with reference to his boasted and yet legitimate inde-

[1] See above, p. 74, note 1, KÖLLIKER, MÜLLER, VERANY and VOGT, etc.

[2] RÜPPELL, (ED.,) Mémoire sur le Magilus antiquus, Trans. Soc. Strasb., 1832, I., fig.

pendence. All relations in nature are regulated by a superior wisdom. May we only learn in the end to conform, within the limits of our own sphere, to the laws assigned to each race!

SECTION XXXI.

COMBINATION IN TIME AND SPACE OF VARIOUS KINDS OF RELATIONS AMONG ANIMALS.

It must occur to every reflecting mind, that the mutual relation and respective parallelism of so many structural, embryonic, geological, and geographical characteristics of the animal kingdom are the most conclusive proof, that they were ordained by a reflective mind, while they present at the same time the side of nature most accessible to our intelligence, when seeking to penetrate the relations between finite beings and the cause of their existence.

The phenomena of the inorganic world are all simple, when compared to those of the organic world. There is not one of the great physical agents, electricity, magnetism, heat, light, or chemical affinity, which exhibits, in its sphere, as complicated phenomena as the simplest organized beings; and we need not look for the highest among the latter, to find them presenting the same physical phenomena as are manifested in the material world, besides those which are exclusively peculiar to them. When, then, organized beings include every thing the material world contains, and a great deal more that is peculiarly their own, how could they be produced by physical causes, and how can the physicists, acquainted with the laws of the material world, and who acknowledge that these laws must have been established at the beginning, overlook that *à fortiori* the more complicated laws which regulate the organic world, of the existence of which there is no trace for a long period upon the surface of the earth, must have been established, later and successively, at the time of the creation of the successive types of animals and plants?

Thus far, we have been considering chiefly the contrasts existing between the organic and inorganic worlds.[1] At this stage of our investigation it may not be out of place to take a glance at some of the coincidences which may be traced between them, especially as they afford direct evidence that the physical world has been ordained in conformity with laws which obtain also among living beings, and disclose, in both spheres equally plainly, the workings of a reflective mind.

[1] Compare Sects. 24, 25, 26, 27, 28, 29, and 30.

It is well known, that the arrangement of the leaves in plants[1] may be expressed by very simple series of fractions, all of which are gradual approximations to, or the natural means between $\frac{1}{2}$ or $\frac{1}{3}$, which two fractions are themselves the maximum and the minimum divergence between two single successive leaves. The normal series of fractions which expresses the various combinations most frequently observed among the leaves of plants, is as follows: $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, etc. Now, upon comparing this arrangement of the leaves in plants with the revolutions of the members of our solar system, Peirce has discovered the most perfect identity between the fundamental laws which regulate both, as may be at once seen by the following diagram, in which the first column gives the names of the planets, the second column indicates the actual time of revolution of the successive planets, expressed in days, the third column the successive times of revolution of the planets, which are derived from the hypothesis that each time of revolution should have a ratio to those upon each side of it, which shall be one of the ratios of the law of phyllotaxis; and the fourth column, finally, gives the normal series of fractions expressing the law of the phyllotaxis.

Neptune,	60,129	62,000	
Uranus,	30,687	31,000	$\frac{1}{2}$
Saturn,	10,759	10,333	$\frac{1}{3}$
Jupiter,	4,333	4,133	$\frac{2}{5}$
Asteroids,	1,200 to 2,000	1,550	$\frac{3}{8}$
Mars,	687	596	$\frac{5}{13}$
Earth,	365	366	$\frac{8}{13}$ } $\frac{8}{21}$
Venus,	225	227	$\frac{13}{21}$ }
Mercury,	88	87	$\frac{13}{34}$

In this series the Earth forms a break; but this apparent irregularity admits of an easy explanation. The fractions $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{24}$, etc., as expressing the position of successive leaves upon an axis, by the short way of ascent along the spiral, are identical, as far as their meaning is concerned, with the fractions expressing these same positions, by the long way, namely, $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{5}{8}$, $\frac{8}{13}$, $\frac{13}{21}$, $\frac{21}{34}$, etc.

Let us, therefore, repeat our diagram in another form, the third column giving the theoretical time of revolution.

Neptune,	$\frac{1}{1}$	62,000	60,129
"	$\frac{1}{1}$	62,000	——
Uranus,	$\frac{1}{2}$	31,000	30,687
"	$\frac{1}{2}$	15.500	——

[1] See the works quoted above, p. 18, note 3.

Saturn,	$\frac{2}{3}$	10,333	10,759
"	$\frac{2}{3}$	6,889	——
Jupiter,	$\frac{3}{5}$	4,133	4,333
"	$\frac{3}{5}$	2,480	——
Asteroids,	$\frac{5}{8}$	1,550	1,200
"	$\frac{5}{8}$	968	——
Mars,	$\frac{8}{13}$	596	687
Earth,	$\frac{8}{13}$	366	365
Venus,	$\frac{13}{21}$	227	225
"	$\frac{13}{21}$	140	——
Mercury,	$\frac{21}{34}$	87	88

It appears from this table, that two intervals usually elapse between two successive planets, so that the normal order of actual fractions is $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, etc., or the fractions by the short way in phyllotaxis, from which, however, the Earth is excluded, while it forms a member of the series by the long way. The explanation of this, suggested by Peirce, is that although the tendency to set off a planet is not sufficient at the end of a single interval, it becomes so strong near the end of the second interval, that the planet is found exterior to the limit of this second interval. Thus, Uranus is rather too far from the Sun relatively to Neptune, Saturn relatively to Uranus, and Jupiter relatively to Saturn, and the planets thus formed engross too large a proportionate share of material, and this is especially the case with Jupiter. Hence, when we come to the Asteroids, the disposition is so strong at the end of a single interval, that the outer Asteroid is but just within this interval, and the whole material of the Asteroids is dispersed in separate masses over a wide space, instead of being concentrated into a single planet. A consequence of this dispersion of the forming agents is, that a small proportionate material is absorbed into the Asteroids. Hence, Mars is ready for formation so far exterior to its true place, that when the next interval elapses the residual force becomes strong enough to form the Earth, after which the normal law is resumed without any further disturbance. Under this law, there can be no planet exterior to Neptune, but there may be one interior to Mercury.

Let us now look back upon some of the leading features alluded to before, omitting the simpler relations of organized beings to the world around, or those of individuals to individuals, to consider only the different parallel series we have been comparing when showing that, in their respective great types, the phenomena of animal life correspond to one another, whether we compare their rank as determined by structural complication with the phases of their growth, or with their succession in past geological ages; whether we compare this succession with their embryonic growth, or all these different relations with each other and with the geo-

graphical distribution of animals upon earth. The same series everywhere![1] These facts are true of all the great divisions of the animal kingdom, so far as we have pursued the investigation; and though, for want of materials, the train of evidence is incomplete in some instances, yet we have proof enough for the establishment of this law of a universal correspondence in all the leading features which binds all organized beings, of all times, into one great system, intellectually and intelligibly linked together, even where some links of the chain are missing. It requires considerable familiarity with the subject even to keep in mind the evidence, for, though yet imperfectly understood, it is the most brilliant result of the combined intellectual efforts of hundreds of investigators during half a century. The connection, however, between the facts, it is easily seen, is only intellectual; and implies, therefore, the agency of Intellect as its first cause.[2]

And if the power of thinking connectedly is the privilege of cultivated minds only; if the power of combining different thoughts, and of drawing from them new thoughts, is a still rarer privilege of a few superior minds; if the ability to trace simultaneously several trains of thought is such an extraordinary gift, that the few cases in which evidence of this kind has been presented have become a matter of historical record (Cæsar dictating several letters at the same time), though they exhibit only the capacity of passing rapidly, in quick succession, from one topic to another, while keeping the connecting thread of several parallel thoughts: if all this is only possible for the highest intellectual powers, shall we by any false argumentation allow ourselves to deny the intervention of a Supreme Intellect in calling into existence combinations in nature, by the side of which, all human conceptions are child's play?

If I have succeeded, even very imperfectly, in showing that the various relations observed between animals and the physical world, as well as between themselves, exhibit thought, it follows, that the whole has an Intelligent Author, and it may not be out of place to attempt to point out, as far as possible, the difference there may be between Divine thinking and human thought.

Taking nature as exhibiting thought for my guide, it appears to me, that while human thought is consecutive, Divine thought is simultaneous, embracing at the same time and for ever, in the past, the present, and the future, the most diversified relations among hundreds of thousands of organized beings, each of which may present complications again, which, to study and understand even imperfectly, as for instance, Man himself, Mankind has already spent thousands of years. And yet, all this has been done by one Mind, must be the work of one Mind only, of

[1] Compare all the preceding sections, where every topic is considered separately.

[2] AGASSIZ, (L.,) Contemplations of God in the Kosmos, Christian Examiner, January, 1851, Boston.

Him before whom Man can only bow in grateful acknowledgment of the prerogatives he is allowed to enjoy in this world, not to speak of the promises of a future life.

I have intentionally dismissed many points in my argument with mere questions, in order not to extend unduly a discussion which is after all only accessory to the plan of my work. I have felt justified in doing so because, from the point of view under which my subject is treated, those questions find a natural solution which must present itself to every reader. We know what the intellect of Man may originate, we know its creative power, its power of combination, of foresight, of analysis, of concentration; we are, therefore, prepared to recognize a similar action emanating from a Supreme Intelligence to a boundless extent. We need, therefore, not even attempt to show that such an Intellect may have originated all the Universe contains; it is enough to demonstrate, that the constitution of the physical world, and more particularly the organization of living beings in their connection with the physical world prove, in general, the existence of a Supreme Being, as the Author of all things. The task of science is rather to investigate what has been done, to inquire, if possible, how it has been done, than to ask what is possible for the Deity, as we can know that only by what actually exists. To attack such a position, those who would deny the intervention in nature of a creative mind, must show, that the cause to which they refer the origin of finite beings is by its nature a possible cause, which cannot be denied of a being endowed with the attributes we recognize in God. Our task is therefore completed, as soon as we have proved his existence. It would, nevertheless, be highly desirable that every naturalist, who has arrived at similar conclusions, should go over the subject anew, from his point of view and with particular reference to the special field of his investigations; for so only can the whole evidence be brought out.

I foresee already that some of the most striking illustrations may be drawn from the morphology of the vegetable kingdom, especially from the characteristic succession and systematical combination of different kinds of leaves in the formation of the foliage and the flowers of so many plants, all of which end their development by the production of an endless variety of fruits. The inorganic world, considered in the same light, would not fail to exhibit also unexpected evidence of thought, in the character of the laws regulating the chemical combinations, the action of physical forces, the universal attraction, etc., etc. Even the history of human culture ought to be investigated from this point of view. But I must leave it to abler hands to discuss such topics.

SECTION XXXII.

RECAPITULATION.

In recapitulating the preceding statements, we may present the following conclusions:—

1st.[1] The connection of all these known features of nature into one system exhibits thought, the most comprehensive thought, in limits transcending the highest wonted powers of man.

2d. The simultaneous existence of the most diversified types under identical circumstances exhibits thought, the ability to adapt a great variety of structures to the most uniform conditions.

3d. The repetition of similar types, under the most diversified circumstances, shows an immaterial connection between them; it exhibits thought, proving directly how completely the Creative Mind is independent of the influence of a material world.

4th. The unity of plan in otherwise highly diversified types of animals, exhibits thought; it exhibits more immediately premeditation, for no plan could embrace such a diversity of beings, called into existence at such long intervals of time, unless it had been framed in the beginning with immediate reference to the end.

5th. The correspondence, now generally known as special homologies, in the details of structure in animals otherwise entirely disconnected, down to the most minute peculiarities, exhibits thought, and more immediately the power of expressing a general proposition in an indefinite number of ways, equally complete in themselves, though differing in all their details.

6th. The various degrees and different kinds of relationship among animals which can have no genealogical connection, exhibit thought, the power of combining different categories into a permanent, harmonious whole, even though the material basis of this harmony be ever changing.

7th. The simultaneous existence, in the earliest geological periods in which animals existed at all, of representatives of all the great types of the animal kingdom, exhibits most especially thought, considerate thought, combining power, premeditation, prescience, omniscience.

8th. The gradation based upon complications of structure which may be traced

[1] The numbers inscribed here correspond to the preceding sections, in the same order, so that the reader may at once refer back to the evidence, when needed.

among animals built upon the same plan, exhibits thought, and especially the power of distributing harmoniously unequal gifts.

9th. The distribution of some types over the most extensive range of the surface of the globe, while others are limited to particular geographical areas, and the various combinations of these types into zoölogical provinces of unequal extent, exhibit thought, a close control in the distribution of the earth's surface among its inhabitants.

10th. The identity of structure of these types, notwithstanding their wide geographical distribution, exhibits thought, that deep thought which, the more it is scrutinized, seems the less capable of being exhausted, though its meaning at the surface appears at once plain and intelligible to every one.

11th. The community of structure in certain respects of animals otherwise entirely different, but living within the same geographical area, exhibits thought, and more particularly the power of adapting most diversified types with peculiar structures to either identical or to different conditions of existence.

12th. The connection, by series, of special structures observed in animals widely scattered over the surface of the globe, exhibits thought, unlimited comprehension, and more directly omnipresence of mind, and also prescience, as far as such series extend through a succession of geological ages.

13th. The relation there is between the size of animals and their structure and form, exhibits thought; it shows that in nature the quantitative differences are as fixedly determined as the qualitative ones.

14th. The independence, in the size of animals, of the mediums in which they live, exhibits thought, in establishing such close connection between elements so influential in themselves and organized beings so little affected by the nature of these elements.

15th. The permanence of specific peculiarities under every variety of external influences, during each geological period, and under the present state of things upon earth, exhibits thought: it shows, also, that limitation in time is an essential element of all finite beings, while eternity is an attribute of the Deity only.

16th. The definite relations in which animals stand to the surrounding world, exhibit thought; for all animals living together stand respectively, on account of their very differences, in different relations to identical conditions of existence, in a manner which implies a considerate adaptation of their varied organization to these uniform conditions.

17th. The relations in which individuals of the same species stand to one another, exhibit thought, and go far to prove the existence in all living beings of an immaterial, imperishable principle, similar to that which is generally conceded to man only.

18th. The limitation of the range of changes which animals undergo during their growth, exhibits thought; it shows most strikingly the independence of these changes of external influences, and the necessity that they should be determined by a power superior to these influences.

19th. The unequal limitation in the average duration of the life of individuals in different species of animals, exhibits thought; for, however uniform or however diversified the conditions of existence may be under which animals live together, the average duration of life, in different species, is unequally limited. It points, therefore, at a knowledge of time and space, and of the value of time, since the phases of life of different animals are apportioned according to the part they have to perform upon the stage of the world.

20th. The return to a definite norm of animals which multiply in various ways, exhibits thought. It shows how wide a cycle of modulations may be included in the same conception, without yet departing from a norm expressed more directly in other combinations.

21st. The order of succession of the different types of animals and plants characteristic of the different geological epochs, exhibits thought. It shows, that while the material world is identical in itself in all ages, ever different types of organized beings are called into existence in successive periods.

22d. The localization of some types of animals upon the same points of the surface of the globe, during several successive geological periods, exhibits thought, consecutive thought; the operations of a mind acting in conformity with a plan laid out beforehand and sustained for a long period.

23d. The limitation of closely allied species to different geological periods, exhibits thought; it exhibits the power of sustaining nice distinctions, notwithstanding the interposition of great disturbances by physical revolutions.

24th. The parallelism between the order of succession of animals and plants in geological times, and the gradation among their living representatives, exhibit thought; consecutive thought, superintending the whole development of nature from beginning to end, and disclosing throughout a gradual progress, ending with the introduction of man at the head of the animal creation.

25th. The parallelism between the order of succession of animals in geological times and the changes their living representatives undergo during their embryological growth, exhibits thought; the repetition of the same train of thoughts in the phases of growth of living animals and the successive appearance of their representatives in past ages.

26th. The combination, in many extinct types, of characters which, in later ages, appear disconnected in different types, exhibits thought, prophetic thought, foresight; combinations of thought preceding their manifestation in living forms.

27th. The parallelism between the gradation among animals and the changes they undergo during their growth, exhibits thought, as it discloses everywhere the most intimate connection between essential features of animals which have no necessary physical relation, and can, therefore, not be understood otherwise than as established by a thinking being.

28th. The relations existing between these different series and the geographical distribution of animals, exhibit thought; they show the omnipresence of the Creator.

29th. The mutual dependence of the animal and vegetable kingdoms for their maintenance, exhibits thought; it displays the care with which all conditions of existence, necessary to the maintenance of organized beings, have been balanced.

30th. The dependence of some animals upon others or upon plants for their existence, exhibits thought; it shows to what degree the most complicated combinations of structure and adaptation can be rendered independent of the physical conditions which surround them.

We may sum up the results of this discussion, up to this point, in still fewer words:—

All organized beings exhibit in themselves all those categories of structure and of existence upon which a natural system may be founded, in such a manner that, in tracing it, the human mind is only translating into human language the Divine thoughts expressed in nature in living realities.

All these beings do not exist in consequence of the continued agency of physical causes, but have made their successive appearance upon earth by the immediate intervention of the Creator. As proof, I may sum up my argument in the following manner:

The products of what are commonly called physical agents are everywhere the same, (that is, upon the whole surface of the globe,) and have always been the same (that is, during all geological periods); while organized beings are everywhere different and have differed in all ages. Between two such series of phenomena there can be no causal or genetic connection.

31st. The combination in time and space of all these thoughtful conceptions exhibits not only thought, it shows also premeditation, power, wisdom, greatness, prescience, omniscience, providence. In one word, all these facts in their natural connection proclaim aloud the One God, whom man may know, adore, and love; and Natural History must, in good time, become the analysis of the thoughts of the Creator of the Universe, as manifested in the animal and vegetable kingdoms.

It may appear strange that I should have included the preceding disquisition in that part of my work which is headed Classification. Yet, it has been done

deliberately. In the beginning of this chapter, I have already stated that Classification seems to me to rest upon too narrow a foundation when it is chiefly based upon structure. Animals are linked together as closely by their mode of development, by their relative standing in their respective classes, by the order in which they have made their appearance upon earth, by their geographical distribution, and generally by their connection with the world in which they live, as by their anatomy. All these relations should, therefore, be fully expressed in a natural classification; and though structure furnishes the most direct indication of some of these relations, always appreciable under every circumstance, other considerations should not be neglected, which may complete our insight into the general plan of creation.

In characterizing the great branches of the animal kingdom, it is not enough to indicate the plan of their structure, in all its peculiarities; there are possibilities of execution which are at once suggested to the exclusion of others, and which should also be considered, and so fully analyzed, that the various modes in which such a plan may be carried out shall at once be made apparent. The range and character of the general homologies of each type should also be illustrated, as well as the general conditions of existence of its representatives. In characterizing classes, it ought to be shown why such groups constitute a class and not merely an order, or a family; and to do this satisfactorily, it is indispensable to trace the special homologies of all the systems of organs which are developed in them. It is not less important to ascertain the foundation of all the subordinate divisions of each class; to know how they differ, what constitutes orders, what families, what genera, and upon what characteristics species are based in every natural division. This we shall examine in the next chapter.


PATRE SVO
A CAROLO DARWIN
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FRANCISCVS DARWIN
Harry Soane. 1882.

PART I. OF THE FIRST VOLUME OF THE

CONTRIBUTIONS

TO THE

NATURAL HISTORY OF THE UNITED STATES

OF

NORTH AMERICA.

BY

L. AGASSIZ.

CHAPTER SECOND.

LEADING GROUPS OF THE EXISTING SYSTEMS OF ANIMALS.

SECTION I.

GREAT TYPES OR BRANCHES OF THE ANIMAL KINGDOM.

THE use of the terms types, classes, orders, families, genera, and species in the systems of Zoölogy and Botany is so universal, that it would be natural to suppose that their meaning and extent are well determined and generally understood; but this is so far from being the case, that it may, on the contrary, be said, there is no subject in Natural History respecting which there exists more uncertainty and a greater want of precision. Indeed, I have failed to find anywhere a definition of the character of most of the more comprehensive of these divisions, while the current views respecting genera and species are very conflicting. Under these circumstances, it has appeared to me particularly desirable, to inquire into the foundation of these distinctions, and to ascertain, if possible, how far they have a real existence. And while I hope the results of this inquiry may be welcome and satisfactory, I am free to confess that it has cost me years of labor to arrive at a clear conception of their true character.

It is such a universal fact in every sphere of intellectual activity, that practice anticipates theory, that no philosopher should be surprised to find zoölogists have adopted instinctively natural groups, in the animal and vegetable kingdoms, even before the question of the character and of the very existence of such groups in nature was raised. Did not nations speak, understand, and write Greek, Latin, German, and Sanscrit before it was even suspected that these languages and so many others were kindred? Did not painters produce wonders with colors before the nature of light was understood? Had not men been thinking about themselves and the world before logic and metaphysics were taught in schools?

Why, then, should not observers of nature have appreciated rightly the relationship between animals or plants before getting a scientific clue to the classifications they were led to adopt as practical?

Such considerations, above all others, have guided and encouraged me while I was seeking for the meaning of all these systems, so different one from the other in their details, and yet so similar in some of their general features. The history of our science shows how early some of the principles, which obtain to this day, have been acknowledged by all reflecting naturalists. Aristotle, for instance, knew already the principal differences which distinguish Vertebrata from all other animals, and his distinction of *Eneima* and *Aneima*[1] corresponds exactly to that of *Vertebrata* and *Invertebrata* of Lamarck,[2] or to that of *Flesh-* and *Gut-Animals* of Oken,[3] or to that of *Myeloneura* and *Ganglioneura* of Ehrenberg;[4] and one who is at all familiar with the progress of science at different periods, can but smile at the claims to novelty or originality so frequently brought forward for views long before current among men. Here, for instance, is one and the same fact presented in different aspects; first, by Aristotle with reference to the character of the formative fluid, next by Lamarck with reference to the general frame, for I will do Lamarck the justice to believe, that he did not unite the Invertebrata simply because they have no skeleton, but because of that something, which even Professor Owen fails to express,[5] and which yet exists, the one cavity of the body in Invertebrata containing all organs, whilst Vertebrata have one distinct cavity for the centres of the nervous system and another for the organs of the vegetative life. This acknowledgment is due to Lamarck as truly as it would be due to Aristotle not to accuse him of having denied the Invertebrata any fluid answering the office of the blood, though he calls them *Aneima*; for he knew nearly as well as we now know, that there moves a nutritive fluid in their body, though that information is generally denied him, because he had no correct knowledge of the circulation of the blood.

Again, when Oken speaks of Flesh-Animals he does not mean that Vertebrates consist of nothing but flesh, or that the Invertebrates have no muscular fibres; but he brings prominently before us the presence, in the former, of those masses, forming mainly the bulk of the body, which consist of flesh and bones, as well as blood and nerves, and constitute another of the leading features distinguishing Vertebrata and Invertebrata. Ehrenberg presents the same relations between the same beings as expressed by their nervous system. If we now take the expressions

[1] Histor. Anim., Lib. I., Ch. 5 and 6.

[2] Anim. Vert., 2d édit., vol. 1, p. 313.

[3] Naturphilosophie, 3d edit., p. 400.

[4] Das Naturreich des Menschen; a diagram, upon a large sheet, folio.

[5] Comparat. Anat. of Inv., 2d edit., p. 11.

of Aristotle, Lamarck, Oken, and Ehrenberg together, have we not, as characteristic of their systems, the very words by which every one distinguishes the most prominent features of the body of the higher animals, when speaking of blood relations, of blood and bones, or of having flesh and nerve?

Neither of these observers has probably been conscious of the identity of his classification with that of his predecessors; nor, indeed, should we consider either of them as superfluous, inasmuch as it makes prominent, features more or less different from those insisted upon by the others; nor ought any one to suppose that with all of them the field is exhausted, and that there is no more room for new systems upon that very first distinction among animals.[1] As long as men inquire they will have opportunities to know more upon these topics than those who have gone before them, so inexhaustibly rich is nature in the innermost diversity of her treasures of beauty, order, and intelligence.

So, instead of discarding all the systems which have thus far had little or no influence upon the progress of science, either because they are based upon principles not generally acknowledged or considered worthy of confidence, I have carefully studied them with the view of ascertaining whatever there may be true in them, from the stand-point from which their authors have considered the animal kingdom; and I own that I have often derived more information from such a careful consideration than I had at first expected.

It was not indeed by a lucky hit, nor by one of those unexpected apparitions which, like a revelation, suddenly break upon us and render at once clear and comprehensible what had been dark and almost inaccessible before, that I came to understand the meaning of those divisions called types, classes, orders, families, genera, and species, so long admitted in Natural History as the basis of every system, and yet so generally considered as mere artificial devices to facilitate our studies. For years I had been laboring under the impression that they are founded in nature, before I succeeded in finding out upon what principle they were really based. I soon perceived, however, that the greatest obstacle in the way of ascertaining their true significance lay in the discrepancies among different authors in their use and application of these terms. Different naturalists do not call by the same name groups of the same kind and the same extent: some call genera what others call subgenera; others call tribes, or even families, what are called genera by others;

[1] By way of an example, I would mention the mode of reproduction. The formation of the egg in Vertebrata; its origin, in all of them, in a more or less complicated Graafian vesicle, in which it is nursed; the formation and development of the embryo up to a certain period, etc., etc., are so completely different from what is observed in any of the Invertebrata, that the animal kingdom, classified according to these facts, would again be divided into two great groups, corresponding to the *Vertebrata* and *Invertebrata* of Lamarck, or the *Flesh-* and *Gut-Animals* of Oken, or the *Eneima* and *Aneima* of Aristotle, etc.

even the names of tribe and family have been applied by some to what others call sub-genera; some have called families what others have called orders; some consider as orders what others have considered as classes; and there are even genera of some authors which are considered as classes by others. Finally, in the number and limitation of these classes, as well as in the manner in which they are grouped together, under general heads, there is found the same diversity of opinion. It is, nevertheless, possible, that under these manifold names, so differently applied, groups may be designated which may be natural, even if their true relation to one another have thus far escaped our attention.

It is already certain that most, if not all investigators agree in the limitation, of some groups at least, under whatever name they may call them, and however much they would blame one another for calling them so, or otherwise. I can therefore no longer doubt that the controversy would be limited to definite questions, if naturalists could only be led to an agreement respecting the real nature of each kind of groups. I am satisfied, indeed, that the most insuperable obstacle to any exact appreciation of this subject lies in the fact, that all naturalists, without exception, consider these divisions, under whatever name they may designate them, as strictly subordinate one to the other, in such a manner, that their difference is only dependent upon their extent; the class being considered as the more comprehensive division, the order as the next extensive, the family as more limited, the genus as still more limited, and the species as the ultimate limitation in a natural arrangement of living beings, so that all these groups would differ only by the quantity of their characters, and not by the quality, as if the elements of structure in animals were all of the same kind; as if the form, for instance, was an organic element of the same kind as the complication of structure, and as if the degree of complication implied necessarily one plan of structure to the exclusion of another. I trust I shall presently be able to show that it is to a neglect of these considerations that we must ascribe the slow progress which has been made in the philosophy of classification.

Were it possible to show that all these groups do not differ in quantity, and are not merely divisions of a wider or more limited range, but are based upon different categories of characters, genera would be called genera by all, whether they differ much or little one from the other, and so would families be called families, orders be called orders, etc. Could, for instance, species be based upon absolute size, genera upon the structure of some external parts of the body, families upon the form of the body, orders upon the similarity of the internal structure, or the like, it is plain that there could not be two opinions respecting these groups in any class of the animal kingdom. But as the problem is not so simple in nature, it was not until after the most extensive investigations, that I seized the clue to

guide me through this labyrinth. I knew, for instance, that though naturalists have been disputing, and are still disputing, about species and genera, they all distinguished the things themselves in pretty much the same manner. What A would call a species, B called only a variety or a race; but then B might call a subgenus the very same aggregate of individuals which A called a species; or what A called a genus was considered by B as a family or an order. Now it was this something called no matter how, for which I tried to find out characters which would lead all to call it by the same name; thus limiting the practical difficulty in the application of the name to a question of accuracy in the observations, and no longer allowing it to be an eternal contest about mere nomenclature.

At this stage of my investigation it struck me, that the character of the writings of eminent naturalists might throw some light upon the subject itself. There are authors, and among them some of the most celebrated contributors to our knowledge in Natural History, who never busied themselves with classification, or paid only a passing notice to this subject, whilst they are, by universal consent, considered as the most successful biographers of species; such are Buffon, Reaumur, Roesel, Trembley, Smeathman, the two Hubers, Bewick, Wilson, Audubon, Naumann, etc. Others have applied themselves almost exclusively to the study of genera. Latreille is the most prominent zoölogist of this stamp; whilst Linnæus and Jussieu stand highest among botanists for their characteristics of genera, or at least for their early successful attempts at tracing the natural limits of genera. Botanists have thus far been more successful than zoölogists in characterizing natural families, though Cuvier and Latreille have done a great deal in that same direction in Zoölogy, whilst Linnæus was the first to introduce orders in the classification of animals. As to the higher groups, such as classes and types, and even the orders, we find again Cuvier leading the procession, in which have followed all the naturalists of this century.

Now let us inquire what these men have done in particular to distinguish themselves especially, either as biographers of species, or as characterizers of genera, of families, of orders, of classes, and of types. And should it appear that in each case they have been considering their subject from some particular point of view, it strikes me that what has been acknowledged unconsciously as constituting the particular eminence or distinction of these men, might very properly be proclaimed, with grateful consciousness of their services, as the characteristic of that kind of groups which each of them has most successfully illustrated; and I hope every unprejudiced naturalist will agree with me in this respect.

As to the highest divisions of the animal kingdom, first introduced by Cuvier under the name of *embranchements*, (and which we may well render by the good old English word *branch*,) he tells us himself that they are founded upon distinct plans

of structure, cast, as it were, into distinct moulds or forms.[1] Now there can certainly be no reason why we should not all agree to designate as types or branches all such great divisions of the animal kingdom as are constituted upon a special plan,[2] if we should find practically that such groups may be traced in nature. Those who may not see them may deny their existence; those who recognize them may vary in their estimation of their natural limits; but all can, for the greatest benefit of science, agree to call any group which seems to them to be founded upon a special plan of structure, a type or branch of the animal kingdom; and if there are still differences of opinion among naturalists respecting their limits, let the discussion upon this point be carried on with the understanding that types are to be characterized by different plans of structure, and not by special anatomical peculiarities. Let us avoid confounding the idea of plan with that of complication of structure, even though Cuvier himself has made this mistake here and there in his classification.

The best evidence I can produce that the idea of distinct plans of structure is the true pivot upon which the natural limitation of the branches of the animal kingdom is ultimately to turn, lies in the fact that every great improvement, acknowledged by all as such, which these primary divisions have undergone, has consisted in the removal from among each, of such groups as had been placed with them from other considerations than those of a peculiar plan, or in consequence of a want of information respecting their true plan of structure. Let us examine this point within limits no longer controvertible. Neither Infusoria nor Intestinal Worms are any longer arranged by competent naturalists among Radiata. Why they have been removed, may be considered elsewhere; but it was certainly not because they were supposed to agree in the plan of their structure with the

[1] It would lead me too far were I to consider here the characteristics of the different kingdoms of Nature. I may, however, refer to the work of I. GEOFFROY ST. HILAIRE, Histoire naturelle générale des règnes organiques, Paris, 1856, 8vo., who has discussed this subject recently, though I must object to the admission of a distinct kingdom for Man alone.

[2] It is almost superfluous for me to mention here that the terms plan, ways and means, or manner in which a plan is carried out, complication of structure, form, details of structure, ultimate structure, relations of individuals, frequently used in the following pages, are taken in a somewhat different sense from their usual meaning, as is always necessary when new views are introduced in a science, and the adoption of old expressions, in a somewhat modified sense, is found preferable to framing new ones. I trust the value of the following discussion will be appreciated by its intrinsic merit, tested with a willingness to understand what has been my aim, and not altogether by the relative degree of precision and clearness with which I may have expressed myself, as it is almost impossible, in a first attempt of this kind, to seize at once upon the form best adapted to carry conviction. I wish also to be understood as expressing my views more immediately with reference to the animal kingdom, as I do not feel quite competent to extend the inquiry and the discussion to the vegetable kingdom, though I have occasionally alluded to it, as far as my information would permit.

true Radiata, that Cuvier placed them in that division, but simply because he allowed himself to depart from his own principle, and to add another consideration, besides the plan of structure, as characteristic of Radiata, the supposed absence of a nervous system, and the great simplicity of structure of these animals; as if simplicity of execution had any necessary connection with the plan of structure. Another remarkable instance of the generally approved removal of a class from one of the types of Cuvier to another, was the transfer of the Cirripeds from among the Mollusks to the branch of Articulata. Imperfect knowledge of the plan of structure of these animals was here the cause of the mistake, which was corrected without any opposition, as soon as they became better known.

From a comparison of what is stated here respecting the different plans of structure, characteristic of the primary divisions of the animal kingdom, with what I have to say below about classes and orders, it will appear more fully, that it is important to make a distinction between the plan of a structure and the manner in which that plan is carried out, or the degrees of its complication and its relative perfection or simplicity. But even after it is understood that the plan of structure should be the leading characteristic of these primary groups, it does not yet follow, without further examination, that the four great branches of the animal kingdom, first distinguished by Cuvier, are to be considered as the primary divisions which Nature points out as fundamental. It will still be necessary, by a careful and thorough investigation of the subject, to ascertain what these primary groups are; but we shall have gained one point with reference to our systems, that whatever these primary groups, founded upon different plans, which exist in nature, may be, when they are once defined, or whilst they are admitted as the temporary expression of our present knowledge, they should be called the branches of the animal kingdom, whether they be the Vertebrata, Articulata, Mollusca, and Radiata of Cuvier, or the Artiozoaria, Actinozoaria, and Amorphozoaria of Blainville, or the Vertebrata and Invertebrata of Lamarck. The special inquiry into this point must be left for a special paper. I will only add, that I am daily more satisfied, that, in their general outlines, the primary divisions of Cuvier are true to nature, and that never did a naturalist exhibit a clearer and deeper insight into the most general relations of animals than Cuvier, when he perceived, not only that these primary groups are founded upon differences in the plan of their structure, but also how they are essentially related to one another.

Though the term type is generally employed to designate the great fundamental divisions of the animal kingdom, I shall not use it in future, but prefer for it the term branch of the animal kingdom, because the term type is employed in too many different acceptations, and quite as commonly to designate any group of any kind, or any peculiar modification of structure stamped with a distinct and marked

character, as to designate the primary divisions of the animal kingdom. We speak, for instance, of specific types, generic types, family types, ordinal types, classic types, and also of a typical structure. The use of the word type in this sense is so frequent on almost every page of our systematic works, in Zoölogy and in treatises of comparative anatomy, that it seems to me desirable, in order to avoid every possible equivocation in the designation of the most important great primary divisions among animals, to call them branches of the animal kingdom, rather than types.

That, however, our systems are more true to nature than they are often supposed to be, seems to me to be proved by the gradual approximation of scientific men to each other, in their results, and in the forms by which they express those results. The idea which lies at the foundation of the great primary divisions of the animal kingdom is, the most general conception possible in connection with the plan of a definite creation; these divisions are therefore the most comprehensive of all, and properly take the lead in a natural classification, as representing the first and broadest relations of the different natural groups of the animal kingdom, the general formula which they each obey. What we call branches expresses, in fact, a purely ideal connection between animals, the intellectual conception which unites them in the creative thought. It seems to me that the more we examine the true significance of this kind of groups, the more we shall be convinced that they are not founded upon material relations. The lesser divisions which succeed next are founded upon special qualifications of the plan, and differ one from the other by the character of these qualifications. Should it be found that the features in the animal kingdom which, next to the plan of structure, extend over the largest divisions, are those which determine their rank or respective standing, it would appear natural to consider the orders as the second most important category in the organization of animals. Experience, however, shows that this is not the case; that the manner in which the plan of structure is executed leads to the distinction of more extensive divisions (the classes) than those which are based upon the complication of structure (the orders). As a classification can be natural only as far it expresses real relations observed in nature, it follows, therefore, that classes take the second position in a system, immediately under the branches. We shall see below that orders follow next, as they constitute naturally groups that are more comprehensive than families, and that we are not at liberty to invert their respective position, nor to transfer the name of one of these divisions to the other, at our own pleasure, as so many naturalists are constantly doing.

SECTION II.

CLASSES OF ANIMALS.

Before Cuvier had shown that the whole animal kingdom is constructed upon four different plans of structure, classes were the highest groups acknowledged in the systems of Zoölogy, and naturalists very early understood upon what this kind of division should be founded, in order to be natural, even though in practice they did not always perceive the true value of the characters upon which they established their standard of relationship. Linnæus, the first expounder of the system of animals, already distinguishes, by anatomical characters, the classes he has adopted, though very imperfectly; and ever since, systematic writers have aimed at drawing a more and more complete picture of the classes of animals, based upon a more or less extensive investigation of their structure.

Structure, then, is the watchword for the recognition of classes, and an accurate knowledge of their anatomy the surest way to discover their natural limits. And yet, with this standard before them, naturalists have differed, and differ still greatly, in the limits they assign to classes, and in the number of them they adopt. It is really strange, that, applying apparently the same standard to the same objects, the results of their estimation should so greatly vary; and it was this fact which led me to look more closely into the matter, and to inquire whether, after all, the seeming unity of standard was not more a fancied than a real one. Structure may be considered from many points of view: first, with reference to the plan adopted in framing it; secondly, with reference to the work to be done by it, and to the ways and means employed in building it up; thirdly, with reference to the degrees of perfection or complication it exhibits, which may differ greatly, even though the plan be the same, and the ways and means employed in carrying out such a plan should not differ in the least; fourthly, with reference to the form of the whole structure and its parts, which bears no necessary relation, at all events no very close relation, to the degree of perfection of the structure, nor to the manner in which its plan is executed, nor to the plan itself, as a comparison between Bats and Birds, between Whales and Fishes, or between Holothurians and Worms, may easily show; fifthly and lastly, with reference to its last finish, to the execution of the details in the individual parts.

It would not be difficult to show, that the differences which exist among naturalists in their limitation of classes have arisen from an indiscriminate consideration of the structure of animals, in all these different points of view, and an

equally indiscriminate application of the results obtained, to characterizing classes. Those who have not made a proper distinction between the plan of a structure and the manner in which that plan is actually executed, have either overlooked the importance of the great fundamental divisions of the animal kingdom, or they have unduly multiplied the number of these primary divisions, basing their distinctions upon purely anatomical considerations, that is to say, not upon differences in the character of the general plan of structure, but upon the material development of that plan. Those, again, who have confounded the complication of the structure with the ways and means by which life is maintained through any given combination of systems of organs, have failed in establishing a proper difference between class and ordinal characters, and have again and again raised orders to the rank of classes. For we shall see presently, that natural orders must be based upon the different degrees of complication of structure, exhibited within the limits of the classes, while the classes themselves are characterized by the manner in which the plan of the type is carried out, that is to say, by the various combinations of the systems of organs constituting the body of the representatives of any of the great types of the animal kingdom; or perhaps, still more distinctly, the classes are characterized by the different ways in which life is maintained, and the different means employed in establishing these ways. An example will suffice to show that this distinction implies a marked difference between class and ordinal characters.

Let us compare the Polyps and Acalephs as two classes, without allowing ourselves to be troubled by the different limits assigned to them by different authors. Both are constructed upon the same plan, and belong, on that account, to the type of Radiata. In establishing this fact, we do not consider the actual structure of these animals, whether they have a nervous system or not, whether they have organs of senses or not, whether their muscles are striated or smooth, whether they have a solid frame or an entirely soft body, whether their alimentary cavity has only one opening or two opposite openings, whether it has glandular annexes or not, whether the digested food is distributed in the body one way or another, whether the undigested materials are rejected through the mouth or not, whether the sexes are distinct or not, whether they reproduce themselves only by eggs, or by budding also, whether they are simple or not: all we need know, in order to refer them to the branch of Radiata, is whether the plan of their structure exhibits a general radiated arrangement or not. But, when we would distinguish Polypi, Acalephs, and Echinoderms as classes, or rather, when we would ascertain what are the classes among Radiata, and how many there are, we must inquire into the manner in which this idea of radiation, which lies at the foundation of their plan of structure, is actually expressed in all the animals exhibiting such a plan, and

we find easily, that while in some (the Polypi) the body exhibits a large cavity, divided by radiating partitions into a number of chambers, into which hangs a sac, (the digestive cavity,) open below, so as to pour freely the digested food into the main cavity, whence it is circulated to and fro in all the chambers, by the agency of vibrating cilia; in others, (the Acalephs,) the body is plain and full not to be compared to a hollow sac, traversed only in its thickness by radiating tubes, which arise from a central cavity, (the digestive cavity,) without a free communication with one another for their whole length, etc., etc., while in others still, (the Echinoderms,) there is a tough or rigid envelope to the body, inclosing a large cavity in which are contained a variety of distinct systems of organs, etc.

Without giving here a full description of these classes, I only wish to show, that what truly characterizes them, is not the complication of their structure, (for Hydroid Medusæ are hardly more complicated in their structure than Polyps,) but the manner in which the plan of Radiata is carried out, the ways in which life is maintained in these animals, the means applied to this end; in one word, the combinations of their structural elements. But the moment we would discern what are the orders of these classes, these considerations no longer suffice; their structure has to be viewed in a different light; it is now the complication of these apparatus which may guide us. Actinarians and Halcyonarians among Polypi, as orders, differ, the first by having a larger and usually indefinite number of simple tentacles, an equally large number of internal partitions, etc., while in Halcyonarians the eight tentacles are lobed and complicated, and all the parts are combined in pairs, in definite numbers, etc., differences which establish a distinct standing between them in their class, assigning the latter a higher rank than the former.

It follows, then, from the preceding remarks, that classes are to be distinguished by the manner in which the plan of their type is executed, by the ways and means by which this is done, or, in other words, by the combinations of their structural elements, that is to say, by the combinations of the different systems of organs building up the body of their representatives. We need not consider here the various forms under which the structure is embodied, nor the ultimate details, nor the last finish which this structure may exhibit, as a moment's reflection will convince any one that neither form nor structural details can ever be characteristic of classes.

There is another point to which I would call attention, respecting the characteristics of classes. These great divisions, so important in the study of the animal kingdom, that a knowledge of their essential features is rightly considered as the primary object of all investigations in comparative anatomy, are generally represented as exhibiting each some essential modification of the type to which they

belong. This view, again, I consider to be a mistaken appreciation of the facts, to which Cuvier has already called attention, though his warning has remained unnoticed.[1] There is in reality no difference in the plan of animals belonging to different classes of the same branch. The plan of structure of Polypi is no more a modification of that of Acalephæ, than that of Acalephæ or Echinoderms is a modification of the plan of Polyps; the plan is exactly the same in all three; it may be represented by one simple diagram, and may be expressed in one single word, radiation; it is the manifestation of one distinct, characteristic idea. But this idea is exhibited in nature under the most different forms, and expressed in different ways, by the most diversified combinations of structural modifications and in the most varied relations. In the innumerable representatives of each branch of the animal kingdom, it is not the plan that differs, but the manner in which this plan is executed. In the same manner as the variations played by a skilful artist upon the simplest tune are not modifications of the tune itself, but only different expressions of the same fundamental harmony, just so are neither the classes, nor the orders, nor the families, nor the genera, nor the species of any great type, modifications of its plan, but only its different expressions, the different ways in which the fundamental thought embodied in it is manifested in a variety of living beings.

In studying the characteristics of classes we have to deal with structural features, while in investigating their relations to the branches of the animal kingdom to which they belong, we have only to consider the general plan, the framework, as it were, of that structure, not the structure itself. This distinction leads to an important practical result. Since, in the beginning of this century, naturalists have begun, under the lead of the German physiophilosophers, to compare more closely the structure of the different classes of the animal kingdom, points of resemblance have been noticed between them which had entirely escaped the attention of earlier investigators, structural modifications have been identified, which, at first, seemed to exhibit no similarity, so much so, that step by step these comparisons have been extended over the whole animal kingdom, and it has been asserted, that, whatever may be the apparent differences in the organization of animals, they should be considered as constructed of parts essentially identical. This assumed identity of structure has been called homology.[2] But the progress of science is gradually restricting these comparisons within narrower limits, and it appears now, that the structure of animals is homologous only as far as they belong to the same branch, so much so, that the study of homologies is likely to afford one of the most trustworthy means of testing the natural limits of any of the

[1] CUVIER, Règn. An., 2d edit., p. 48.

[2] See Chap. I., Sect. 5.

great types of the animal kingdom. While, however, homologies show the close similarity of apparently different structures and the perfect identity of their plan, within the same branches of the animal kingdom, yet, they daily exhibit more and more striking differences, both in plan and structure, between the branches themselves, leading to the suspicion that systems of organs which are generally considered as identical in different types, will, in the end, prove essentially different, as, for instance, the so-called gills in Fishes, Crustacea, and Mollusks.

It requires no great penetration to see already that the gills of Crustacea are homologous with the tracheæ of Insects and the so-called lungs of certain spiders, in the same manner as the gills of aquatic Mollusks are homologous with the so-called lungs of our air-breathing snails and slugs. Now, until it can be shown that all these different respiratory organs are truly homologous, I hold it to be more natural to consider the system of respiratory organs in Mollusks, in Articulates, and in Vertebrates, as essentially different among themselves, though homologous within the limits of each type; and this remark I would extend to all their systems of organs, to their solid frame, to their nervous system, to their muscular system, to their digestive apparatus, to their circulation, and to their reproductive organs, etc. It would not be difficult to show now that the alimentary canal with its glandular appendages, in Vertebrata, is formed in an entirely different way from that of Articulates or Mollusks, and that it cannot be considered as homologous in all these types. And if this be true, we must expect soon an entire reform of our methods of illustrating comparative anatomy.

Finally, it ought to be remembered, in connection with the study of classes as well as that of other groups, that the amount of difference existing between any two divisions is nowhere the same. Some features in nature seem to be insisted upon with more tenacity than others, to be repeated more frequently and more widely, and to be impressed upon a larger number of representatives. This unequal weight of different groups, so evident everywhere in the animal kingdom, ought to make us more cautious in estimating their natural limits, and prevent us from assigning an undue value to the differences observed between living beings, never overrating apparently great discrepancies, nor underrating seemingly trifling variations. The right path, however, can only be ascertained by extensive investigations, made with special reference to this point.

Everybody must know that the males and females of some species differ much more one from the other than many species do, and yet the amount of difference observed between species is constantly urged, even without a preliminary investigation, as an argument for distinguishing them. These differences, moreover, are not only quantitative, they are to a still greater extent also qualitative. In the

same manner do genera differ more or less one from the other, even in the same family; and such inequality, and not an equable apportionment, is the norm throughout nature. In classes, it is not only exhibited in the variety of their forms, but also, to an extraordinary extent, in their numbers, as, for instance, in the class of Insects compared to that of Worms or Crustacea. The primary divisions of the animal kingdom differ in the same manner one from the other. Articulata are by far the most numerous branch of the whole animal kingdom; their number exceeding greatly that of all other animals put together. Such facts are in themselves sufficient to show how artificial classifications must be which admit only the same number and the same kind of divisions for all the types of the animal kingdom.

SECTION III.

ORDERS AMONG ANIMALS.

Great as is the discrepancy between naturalists respecting the number and limits of classes in the animal kingdom, their disagreement in regard to orders and families is yet far greater. These conflicting views, however, do not in the least shake my confidence in the existence of fixed relations between animals, determined by thoughtful considerations. I would as soon cease to believe in the existence of one God, because men worship Him in so many different ways, or because they even worship gods of their own making, as distrust the evidence of my own senses respecting the existence of a preëstablished and duly considered system in nature, the arrangement of which preceded the creation of all things that exist.

From the manner in which orders are generally characterized and introduced into our systems, it would seem as if this kind of groups were interchangeable with families. Most botanists make no difference even between orders and families, and take almost universally the terms as mere synonyms. Zoölogists have more extensively admitted a difference between them, but while some consider the orders as superior, others place families higher; others admit orders without at the same time distinguishing families, and *vice versâ* introduce families into their classification without admitting orders; others still admit tribes as intermediate groups between orders and families. A glance at any general work on Zoölogy or Botany may satisfy the student how utterly arbitrary the systems are in this respect. The *Règne animal* of Cuvier exhibits even the unaccountable feature, that while orders

and families are introduced in some classes,[1] only orders are noticed in others,[2] and even some exhibit only a succession of genera under the head of their class, without any further grouping among them into orders or families.[3] Other classifications exhibit the most pedantic uniformity of a regular succession in each class, of sub-classes, orders, sub-orders, families, sub-families, tribes, sub-tribes, genera, sub-genera, divisions, sections, and sub-divisions, sub-sections, etc., but bear upon their face, that they are made to suit preconceived ideas of regularity and symmetry in the system, and that they are by no means studied from nature.

To find out the natural characters of orders from that which really exists in nature, I have considered attentively the different systems of Zoölogy in which orders are admitted and apparently considered with more care than elsewhere, and in particular the *Systema Naturæ* of Linnæus, who first introduced in Zoölogy that kind of groups, and the works of Cuvier, in which orders are frequently characterized with unusual precision, and it has appeared to me that the leading idea prevailing everywhere respecting orders, where these groups are not admitted at random, is that of a definite rank among them, the desire to determine the relative standing of these divisions, to ascertain their relative superiority or inferiority, as the name order, adopted to designate them, already implies. The first order in the first class of the animal kingdom, according to the classification of Linnæus, is called by him *Primates*, expressing, no doubt, his conviction that these beings, among which Man is included, rank uppermost in their class. Blainville uses here and there the expression of "degrees of organization," to designate orders. It is true Lamarck uses the same expression to designate classes. We find, therefore, here as everywhere, the same vagueness in the definition of the different kinds of groups adopted in our systems. But if we would give up any arbitrary use of these terms, and assign to them a definite scientific meaning, it seems to me most natural, and in accordance with the practice of the most successful investigators of the animal kingdom, to call orders such divisions as are characterized by different degrees of complication of their structure, within the limits of the classes. As such I would consider, for instance, the Actinoids and Halcyonoids in the class of Polypi, as circumscribed by Dana; the Hydroids, the Discophoræ, and the Cte-

[1] In the classes Mammalia, Birds, Reptiles, and Fishes, Cuvier distinguishes mostly families as well as orders. In the class of Mammalia, some orders number no families, whilst others are divided into tribes instead of families. In the class of Gasteropods, Annelids, Intestinal Worms, and Polyps, some of the orders only are divided into families, while the larger number are not.

[2] The classes Echinoderms, Acalephs, and Infusoria, are divided into orders, but without families.

[3] Such are his classes of Cephalopods, Pteropods, Brachiopods, and Cirripeds (Cirrhopods.) Of the Cephalopods, he says, however, they constitute but one order (Règn. An. vol. 3, p. 11), and, p. 22, he calls them a family, and yet he distinguishes them as a class, p. 8.

noids among Acalephs; the Crinoids, Asterioids, Echinoids, and Holothuriæ among Echinoderms; the Bryozoa, Brachiopods, Tunicata, Lamellibranchiata among Acephala; the Branchifera and Pulmonata among Gasteropods; the Ophidians, the Saurians, and the Chelonians among Reptiles; the Ichthyoids and the Anoura among Amphibians, etc.

Having shown in the preceding paragraph that classes rank next to branches, it would be proper I should show here that orders are natural groups which stand above families in their respective classes; but for obvious reasons I have deferred this discussion to the following paragraph, which relates to families, as it will be easier for me to show what is the respective relation of these two kinds of groups after their special character has been duly considered.

From the preceding remarks respecting orders it might be inferred that I deny all gradation among all other groups, or that I assume that orders constitute necessarily one simple series in each class. Far from asserting any such thing, I hold on the contrary, that neither is necessarily the case. But to explain fully my views upon this point, I must introduce here some other considerations. It will be obvious, from what has already been said, (and the further illustration of this subject will only go to show to what extent this is true,) that there exists an unquestionable hierarchy between the different kinds of groups admitted in our systems, based upon the different kinds of relationship observed among animals, that branches are the most comprehensive divisions, including each several classes, that orders are subdivisions of the classes, families subdivisions of orders, genera subdivisions of families, and species subdivisions of the genera; but not in the sense that each type should necessarily include the same number of classes, nor even necessarily several classes, as this must depend upon the manner in which the type is carried out. A class, again, might contain no orders,[1] if its representatives presented no different degrees characterized by the greater or less complication of their structure; or it may contain many, or few, as these gradations are more or less numerous and well marked; but as the representatives of any and every class have of necessity a definite form, each class must contain at least one family, or many families, indeed, as many as there are systems of forms under which its representatives may be combined, if form can be shown to be characteristic of families. The same is the case with genera and species; and nothing is more remote from the truth than the idea that a genus is better defined in proportion as it contains a greater number of species, or that it may be necessary to know several species of a genus before its existence can be fully ascertained. A genus may be more satisfactorily characterized, its peculiarity more fully ascer-

[1] See Chap. I. Sect. 1.

tained, its limits better defined, when we know all its representatives; but I am satisfied that any natural genus may be at least pointed out, however numerous its species may be, from the examination of any single one of them. Moreover, the number of genera, both in the animal and vegetable kingdom, which contain but a single species, is so great that it is a matter of necessity in all these cases to ascertain their generic characteristics from that one species. Again, such species require to be characterized with as much precision, and their specific characters to be described with as much minuteness, as if a host of them, but not yet known, existed besides. It is a very objectionable practice among zoölogists and botanists, to remain satisfied in such cases with characterizing the genus, and perhaps to believe, what some writers have actually stated distinctly, that in such cases generic and specific characters are identical.

Such being the natural relations and the subordination of types, classes, orders, families, genera, and species, I believe, nevertheless, that neither types, nor classes, (orders of course not at all,) nor families, nor genera, nor species have the same standing when compared among themselves. But this does not in the least interfere with the prominent features of orders, for the relative standing of types, or classes, or families, or genera, or species does not depend upon the degrees of complication of their structures as that of orders does, but upon other features, as I will now show. The four great types or branches of the animal kingdom, characterized as they are by four different plans of structure, will each stand higher or lower, as the plan itself bears a higher or lower character, and that this may be the case we need only compare Vertebrata and Radiata.[1] The different classes of one type will stand higher or lower, as the ways in which and the means with which, the plan of the type to which they belong is carried out, are of a higher or lower nature. Orders in any or all classes are of course higher or lower according to the degree of perfection of their representatives, or according to the complication or simplicity of their structure. Families may stand higher or lower as the peculiarities of their form are determined by modifications of more or less important systems of organs. Genera may stand higher or lower as the structural peculiarities of the parts constituting the generic characteristics exhibit a higher or lower grade of development. Species, lastly, may stand one above the other, in the same genus, according to the character of their relations to the surrounding world, or that of their representatives to one another. These remarks must make it plain that the respective rank of groups of the same kind among themselves must be determined by the superior or inferior grade of those features upon

[1] I must leave out the details of such comparisons, as a mere mention of the point suffices to suggest them; moreover, any text-book of comparative anatomy may furnish the complete evidence to that effect.

which they are themselves founded; while orders alone are strictly defined by the natural degrees of structural complications exhibited within the limits of the classes.

As to the question, whether orders constitute necessarily one simple series in their respective classes, I would say, that this must depend upon the character of the class itself, or the manner in which the plan of the type is carried out within the limits of the class. If the class is homogeneous, that is, if it is not primarily subdivided into sub-classes, the orders will, of course, form a single series; but if some of its organic systems are developed in a different way from the others, there may be one or several parallel series, each subdivided into gradated orders. This can, of course, only be determined by a much more minute study of the characteristics of classes than has been made thus far, and mere guesses at such an internal arrangement of the classes into series, as those proposed by Kaup or Fitzinger, can only be considered as the first attempts towards an estimation of the relative value of the intermediate divisions which may exist between the classes and their orders.

Oken and the physiophilosophers generally have taken a different view of orders. Their idea is, that orders represent, in their respective classes, the characteristic features of the other types of the animal kingdom. As Oken's Intestinal or Gelatinous animals are characterized by a single system of organs, the intestine, they contain no distinct orders, but each class has three tribes, corresponding to the three classes of this type, which are Infusoria, Polypi, and Acalephs. The tribes of the class of Infusoria, are Infusoria proper, Polypoid Infusoria, and Acalephoid Infusoria; the tribes of the class of Polypi, are Infusorial Polypi, Polypi proper, and Acalephoid Polypi; the tribes of the class Acalephs, are Infusorial Acalephs, Polypoid Acalephs, and Acalephs proper. But the classes of Mollusks which are said to be characterized by two systems of organs, the intestine and the vascular system, contain each two orders, one corresponding to the Intestinal animals, the other to the type of Mollusks, and so Acephala are divided into the order of Gelatinous Acephala and that of Molluscoid Acephala, and the Gasteropods and Cephalopods in the same manner into two orders each. The Articulata are considered as representing three systems of organs, the intestinal, the vascular, and the respiratory systems; hence their classes are divided each into three orders. For instance, the Worms contain an order of Gelatinous Worms, one of Molluscoid Worms, one of Annulate Worms, and the same orders are adopted for Crustacea and Insects. Vertebrata are said to represent five systems, the three lower ones being the intestine, the vessels, and the respiratory organs, the two higher the flesh (that is, bones, muscles, and nerves) and the organs of senses; hence, five orders in each class of this type, as, for example, Gelatinous Fishes, Molluscoid Fishes, Entomoid Fishes, Carnal

Fishes, and Sensual Fishes, and so also in the classes of Reptiles, Birds, and Mammalia.[1]

I have entered into so many details upon these vagaries of the distinguished German philosopher, because these views, however crude, have undoubtedly been suggested by a feature of the animal kingdom, which has thus far been too little studied: I mean the analogies which exist among animals, besides their true affinities, and which cross and blend, under modifications of strictly homological structures, other characters which are only analogical. But it seems to me that the subject of analogies is too little known, the facts bearing upon this kind of relationship being still too obscure, to be taken as the basis of such important groups in the animal kingdom as the orders are, and I would insist upon considering the complication or gradation of structure as the feature which should regulate their limitation, if under order we are to understand natural groups expressing the rank, the relative standing, the superiority or inferiority of animals in their respective classes. Of course, groups thus characterized cannot be considered as mere modifications of the classes, being founded upon a special category of features.

SECTION IV.

FAMILIES.

Nothing is more indefinite than the idea of form, as applied by systematic writers, in characterizing animals. Here, it means a system of the most different figures having a common character, as, for instance, when it is said of Zoophytes that they have a radiated form; there, it indicates any outline which circumscribes the body of animals, when, for instance, animal forms are alluded to in general, instead of designating them simply as animals; here, again, it means the special figure of some individual species. There is in fact no group of the animal kingdom, however extensive or however limited, from the branches down to the species, in which the form is not occasionally alluded to as characteristic. Speaking of Articulates, C. E. v. Baer characterizes them as the type with elongated forms; Mollusks are to him the type with massive forms; Radiates that with peripheric symmetry; Vertebrates that with double symmetry, evidently taking their form in its widest sense as expressing the most general relations of the different dimensions of the

[1] See further developments upon this subject in OKEN's Naturphilosophie, and in his Allgemeine Naturgeschichte, vol. 4, p. 582. Compare also the following chapter.

body to one another. Cuvier speaks of form in general with reference to these four great types as a sort of mould, as it were, in which the different types would seem to have been cast. Again, form is alluded to in characterizing orders; for instance, in the distinction between the Brachyourans and the Macrourans among Crustacea, or between the Saurians, the Ophidians, and the Chelonians. It is mentioned as a distinguishing feature in many families, ex. gr. the Cetacea, the Bats, etc. Some genera are separated from others in the same family on the ground of differences of form; and in almost every description of species, especially when they are considered isolatedly, the form is described at full length. Is there not, in this indiscriminate use of the term of form, a confusion of ideas, a want of precision in the estimation of what ought to be called form and what might be designated by another name? It seems to me to be the case. In the first place, when form is considered as characteristic of Radiata or Articulata, or any other of the great types of the animal kingdom, it is evident that it is not a definite outline and well-determined figure which is meant, but that here the word form is used as synonym for plan. Who, for instance, would describe the tubular body of an Holothuria as characterized by a form similar to that of the Euryale, or that of an Echinus as identical with that of an Asterias? And who does not see that, as far as the form is concerned, Holothuriæ resemble Worms much more than they resemble any other Echinoderm, though, as far as the plan of their structure is concerned, they are genuine Radiates, and have nothing to do with the Articulates?

Again, a superficial glance at any and all the classes of the animal kingdom is sufficient to show that each contains animals of the most diversified forms. What can be more different than Bats and Whales, Herons and Parrots, Frogs and Sirens, Eels and Turbots, Butterflies and Bugs, Lobsters and Barnacles, Nautilus and Cuttlefishes, Slugs and Conchs, Clams and compound Asidians, Pentacrinus and Spatangus, Beroe and Physalia, Actinia and Gorgonia? And yet they belong respectively to the same class, as they are coupled here: Bats and Whales together, etc. It must be obvious, then, that form cannot be a characteristic element of classes, if we would understand any thing definite under that name.

But form has a definite meaning understood everywhere, when applied to well-known animals. We speak, for instance, of the human form; an allusion to the form of a horse or that of a bull conveys at once a distinct idea; everybody would acknowledge the similarity of form of the horse and ass, and knows how to distinguish them by their form from dogs or cats, or from seals and porpoises. In this definite meaning, form corresponds also to what we call figure when speaking of men and women, and it is when taken in this sense, that I would now consider the value of forms as characteristic of different animals. We have seen that form

cannot be considered as a character of branches, nor of classes; let us now examine, further, whether it is a character of species. A rapid review of some of the best known types of the animal kingdom, embracing well-defined genera with many species, will at once show that this cannot be the case, for such species do not generally show the least difference in their forms. Neither the many species of Squirrels, nor the true Mice, nor the Weasels, nor the Bears, nor the Eagles, nor the Falcons, nor the Sparrows, nor the Warblers, nor the genuine Woodpeckers, nor the true Lizards, nor the Frogs, nor the Toads, nor the Skates, nor the Sharks proper, nor the Turbots, nor the Soles, nor the Eels, nor the Mackerels, nor the Sculpins, nor the genuine Shrimps, nor the Crawfishes, nor the Hawkmoths, nor the Geometers, nor the Dorbugs, nor the Spring-Beetles, nor the Tapeworms, nor the Cuttlefishes, nor the Slugs, nor the true Asterias, nor the Sea-Anemones, could be distinguished among themselves, one from the other, by their form only. There may be differences in the proportions of some of their parts, but the pattern of every species belonging to well-defined natural genera is so completely identical that it will never afford specific characters. There are genera in our system which, as they now stand, might be alluded to as examples contrary to this statement; but such genera are still based upon very questionable features, and are likely to be found in the end to consist of unnatural associations of heterogeneous species: at all events, all recent improvements in Zoölogy have gone to limit genera gradually more and more in such a manner, that the species belonging to each have shown successively less and less difference in form, until they have assumed, in that respect, the most homogeneous appearance. Are natural genera any more to be distinguished by their form one from the other? Is there any appreciable difference in the general form,—I say purposely general form, because a more or less prominent nose, larger or smaller ears, longer or shorter claws, etc., do not essentially modify the form,—is there any real difference in the general form between the genera of the most natural families? Do, for instance, the genera of Ursina, the Bears, the Badger, the Wolverines, the Raccoons, differ in form? Do the Phocoidæ, the Delphinoidæ, the Falconinæ, the Turdinæ, the Fringillinæ, the Picinæ, the Scolopacinæ, the Chelonioidæ, the Geckonina, the Colubrina, the Sparoidæ, the Elateridæ, the Pyralidoidæ, the Echinoidæ, etc., differ any more among themselves? Certainly not; though to some extent, there are differences in the form of the representatives of one genus when compared to those of another genus; but when rightly considered, these differences appear only as modifications of the same type of forms. Just as there are more or less elongated ellipses, so do we find the figure of the Badgers somewhat more contracted than that of either the Bears, or the Raccoons, or the Wolverines, that of the Wolverines somewhat more elongated than that of the Raccoons; but the form is here as completely typical

as it is among the Viverrina, or among the Canina, or among the Bradypodidæ, or among the Delphinoidæ, etc., etc. We must, therefore, exclude form from the characteristics of natural genera, or at least introduce it only as a modification of the typical form of natural families.

Of all the natural groups in the animal kingdom there remain then only families and orders, for the distinction of which form can apply as an essential criterion. But these two kinds of groups are just those upon which zoölogists are least agreed, so that it may not be easy to find a division which all naturalists would agree to take as an example of a natural order. Let us, however, do our best to settle the difficulty and suppose, for a moment, that what has been said above respecting the orders is well founded, that orders are natural groups characterized by the degree of complication of their structure, and expressing the respective rank of these groups in their class, then we shall find less difficulty in pointing out some few groups which could be generally considered as orders. I suppose most naturalists would agree, for instance, that among Reptiles the Chelonians constitute a natural order; that among Fishes, Sharks and Skates constitute an order also; and if any one would urge the necessity of associating also the Cyclostomes with them, it would only the better serve my purposes. Ganoids, even circumscribed within narrower limits than those I had assigned to them, and perhaps reduced to the extreme limits proposed for them by J. Müller, I am equally prepared to take as an example, though I have in reality still some objections to this limitation, which, however, do not interfere with my present object. Decapods, among Crustacea, I suppose everybody would also admit as an order, and I do not care here what other families are claimed besides Decapods to complete the highest order of Crustacea. Among Acephala, I trust Bryozoa, Tunicata, Brachiopods, and Lamellibranchiata would be also very generally considered to be natural orders. Among Echinoderms, I suppose Crinoids, Asterioids, Echinoids, and Holothurioids would be conceded also as such natural orders; among Acalephs the Beroids, and perhaps also Discophoræ and Hydroids; while among the Polypi, the Halcyonoids constitute a very natural order when compared with the Actinoids.

Let us now consider these orders with reference to the characteristic forms they include. The forms of the genuine Testudo, of Trionyx, and of Chelonia are very different, one from the other, and yet few orders are so well circumscribed as that of Chelonians. The whole class of Fishes scarcely exhibits greater differences than those observed in the forms of the common Sharks, the Sawfishes, the common Skates, and the Torpedo, not to speak of the Cyclostomes and Myxinoids, if these families were also considered as members of the order of Placoids. Ganoids cannot be circumscribed within narrower limits than those assigned to them by J. Müller, and yet this order, thus limited, contains forms as heterogeneous as the Sturgeons,

the Lepidosteus, the Polypterus, the Amia, and a host of extinct genera and families, not to speak of those families I had associated with them and which Prof. Müller would have removed, which, if included among Ganoids, would add still more heteromorphous elements to this order. Among Decapods, we need only remember the Lobsters and Crabs to be convinced that it is not similarity of form which holds them so closely together as a natural order. How heterogeneous Bryozoa, Brachiopods, and Tunicata are among themselves, as far as their form is concerned, everybody knows who has paid the least attention to these animals.

Unless, then, form be too vague an element to characterize any kind of natural groups in the animal kingdom, it must constitute a prominent feature of families. I have already remarked, that orders and families are the groups upon which zoölogists are least agreed, and to the study and characterizing of which they have paid least attention. Does this not arise simply from the fact, that, on the one hand, the difference between ordinal and class characters has not been understood, and only assumed to be a difference of degree; and, on the other hand, that the importance of the form, as the prominent character of families, has been entirely overlooked? For, though so few natural families of animals are well characterized, or characterized at all, we cannot open a modern treatise upon any class of animals without finding the genera more or less naturally grouped together, under the heading of a generic name with a termination in *idæ* or *inæ* indicating family and sub-family distinctions; and most of these groups, however unequal in absolute value, are really natural groups, though far from designating always natural families, being as often orders or sub-orders, as families or sub-families. Yet they indicate the facility there is, almost without study, to point out the intermediate natural groups between the classes and the genera. This arises, in my opinion, from the fact, that family resemblance in the animal kingdom is most strikingly expressed in the general form, and that form is an element which falls most easily under our perception, even when the observation is made superficially. But, at the same time, form is most difficult to describe accurately, and hence the imperfection of most of our family characteristics, and the constant substitution for such characters of features which are not essential to the family. To prove the correctness of this view, I would only appeal to the experience of every naturalist. When we see new animals, does not the first glance, that is, the first impression made upon us by their form, give us at once a very correct idea of their nearest relationship? We perceive, before examining any structural character, whether a Beetle is a Carabicine, a Longicorn, an Elaterid, a Curculionid, a Chrysomeline; whether a Moth is a Noctuelite, a Geometrid, a Pyralid, etc.; whether a bird is a Dove, a Swallow, a Humming-bird, a Woodpecker, a Snipe, a Heron, etc., etc. But before we can ascertain its genus, we have to study the structure of some characteristic

parts; before we can combine families into natural groups, we have to make a thorough investigation of their whole structure, and compare it with that of other families. So form is characteristic of families; and I can add, from a careful investigation of the subject for several years past, during which I have reviewed the whole animal kingdom with reference to this and other topics connected with classification, that form is the essential characteristic of families.[1] I do not mean the mere outline, but form as determined by structure; that is to say, that families cannot be well defined, nor circumscribed within their natural limits, without a thorough investigation of all those features of the internal structure which combine to determine the form.

The characteristic of the North American Chelonians which follows, may serve as an example how this subject is to be treated. I will only add here, that however easy it is at first, from the general impression made upon us by the form of animals, to obtain a glimpse of what may fairly be called families, few investigations require more patient comparisons than those by which we ascertain the natural range of modifications of any typical form, and the structural features upon which it is based. Comparative anatomy has so completely discarded every thing that relates to Morphology; the investigations of anatomists lean so uniformly towards a general appreciation of the connections and homologies of the organic systems which go to build up the body of animals, that for the purpose of understanding the value of forms and their true foundation, they hardly ever afford any information, unless it be here and there a consideration respecting teleological relations.

Taking for granted, that orders are natural groups characterized by the complication of their structure, and that the different orders of a class express the different degrees of that complication; taking now further for granted, that families are natural groups characterized by their form as determined by structural peculiarities, it follows that orders are the superior kind of division, as we have seen that the several natural divisions which are generally considered as orders, contain each several natural groups, characterized by different forms, that is to say, constituting as many distinct families.

After this discussion it is hardly necessary to add, that families cannot by any means be considered as modifications of the orders to which they belong, if orders are to be characterized by the degrees of complication of their structure, and families

[1] These investigations, which have led to most interesting results, have delayed thus far the publication of the systematic part of the Principles of Zoölogy, undertaken in common with my friend, Dr. A. A. Gould, and which I would not allow to appear before I could revise the whole animal kingdom in this new light, in order to introduce as much precision as possible in its classification.

by their forms. I would also further remark, that there is one question relating to the form of animals, which I have not touched here, and which it is still more important to consider in the study of plants, namely, the mode of association of individuals into larger or smaller communities, as we observe them, particularly among Polyps and Acalephs. These aggregations have not, as far as their form is concerned, the same importance as the form of the individual animals of which they are composed, and therefore seldom afford trustworthy family characters. But this point may be more appropriately considered in connection with the special illustration of our Hydroids, to which my next volume is to be devoted.

I have stated above, that botanists have defined the natural families of plants with greater precision than zoölogists those of animals; I have further remarked also, that most of them make no distinction between orders and families. This may be the result of the peculiar character of the vegetable kingdom, which is not built upon such entirely different plans of structure as are animals of different branches. On the contrary, it is possible to trace among plants a certain gradation between their higher and lower types more distinctly than among animals, even though they do not, any more than animals, constitute a simple series. It seems to me, nevertheless, that if Cryptogams, Gymnosperms, Monocotyledons, and Dicotyledons can be considered as branches of the vegetable kingdom, analogous to Radiata, Mollusks, Articulata, and Vertebrata among animals, such divisions as Fungi, Algæ, Lichens, Mosses, Hepaticæ, and Ferns in the widest sense, may be taken as classes. Diatomaceæ, Confervæ, and Fuci may then be considered as orders; Mosses and Hepaticæ as orders; Equisetaceæ, Ferns proper, Hydropterids, and Lycopodiaceæ as orders also; as they exhibit different degrees of complication of structure, while their natural subdivisions, which are more closely allied in form or habitus, may be considered as families; natural families among plants having generally as distinct a port, as families among animals have a distinct form. We need only remember the Palms, the Coniferæ, the Umbelliferæ, the Compositæ, the Leguminosæ, the Labiatæ, etc., as satisfactory examples of this kind.

SECTION V.

GENERA.

Linnæus already knew very well that genera exist in nature, though what he calls genera constitute frequently groups to which we give at present other names, as we consider many of them as families; but it stands proved by his writings

that he had fully satisfied himself of the real existence of such groups, for he says distinctly in his *Philosophia Botanica*, sect. 169, "Scias characterem non constituere genus, sed genus characterem. Characterem fluere e genere, non genus e charactere. Characterem non esse, ut genus fiat, sed ut genus noscatur."

It is surprising that notwithstanding such clear statements, which might have kept naturalists awake respecting the natural foundation of genera, such loose ideas have become prevalent upon this subject, that at present the number of investigators who exhibit much confidence in the real existence of their own generic distinctions is very limited. And as to what genera really are, the want of precision of ideas appears still greater. Those who have considered the subject at all seem to have come to the conclusion that genera are nothing but groups including a certain number of species agreeing in some more general features than those which distinguish species; thus recognizing no difference between generic and specific characters as such, as a single species may constitute a genus, whenever its characters do not agree with the characters of other species, and many species may constitute a genus, because their specific characters agree to a certain extent among themselves.[1] Far from admitting such doctrines, I hope to be able to show that, however much or however little species may differ among themselves as species, yet they may constitute a natural genus, provided their respective generic characters are identical.

I have stated before, that in order to ascertain upon what the different groups adopted in our systems are founded, I consulted the works of such writers as are celebrated in the annals of science for having characterized with particular felicity any one kind of these groups, and I have mentioned Latreille as prominent among zoölogists for the precision with which he has defined the genera of Crustacea and Insects, upon which he has written the most extensive work extant.[2] An anecdote which I have often heard repeated by entomologists who knew Latreille well, is very characteristic as to the meaning he connected with the idea of genera. At the time he was preparing the work just mentioned, he lost no opportunity of obtaining specimens, the better to ascertain from nature the generic peculiarities of these animals, and he used to apply to the entomologists for contributions to his collection. It was not show specimens he cared to obtain, any would do, for he used to say he wanted them only "to examine their parts." Have we not here a hint, from a master, to teach us what genera are and how they should be characterized? Is it not the special structure of some part or other, which charac-

[1] SPRING, Ueber die naturhistorischen Begriffe von Gattung, Art und Abart, Leipzig, 1838, 1 vol. 8vo.

[2] LATREILLE, Genera Crustaceorum und Insectorum, Paris et Argent. 1806–1809, 4 vols. 8vo.

terizes genera? Is it not the finish of the organization of the body, as worked out in the ultimate details of structure, which distinguishes one genus from another? Latreille, in expressing the want he felt with reference to the study of genera, has given us the key-note of their harmonious relations to one another. Genera are most closely allied groups of animals, differing neither in form, nor in complication of structure, but simply in the ultimate structural peculiarities of some of their parts; and this is, I believe, the best definition which can be given of genera. They are not characterized by modifications of the features of the families, for we have seen that the prominent trait of family difference is to be found in a typical form; and genera of the same family may not differ at all in form. Nor are genera merely a more comprehensive mould than the species, embracing a wide range of characteristics; for species in a natural genus should not present any structural differences, but only such as express the most special relations of their representatives to the surrounding world and to each other. Genera, in one word, are natural groups of a peculiar kind, and their special distinction rests upon the ultimate details of their structure.

SECTION VI.

SPECIES.

It is generally believed that nothing is easier than to determine species, and that of all the degrees of relationship which animals exhibit, that which constitutes specific identity is the most clearly defined. An unfailing criterion of specific identity is even supposed to exist in the sexual connection which so naturally brings together the individuals of the same species in the function of reproduction. But I hold that this is a complete fallacy, or at least a *petitio principii*, not admissible in a philosophical discussion of what truly constitutes the characteristics of species. I am even satisfied that some of the most perplexing problems involved in the consideration of the natural limits of species would have been solved long ago, had it not been so generally urged that the ability and natural disposition of individuals to connect themselves in fertile sexual intercourse was of itself sufficient evidence of their specific identity. Without alluding to the fact that every new case of hybridity[1] is an ever-returning protest against such an assertion, and

[1] WIEGMAN, Gekrönte Preisschrift über die Bastarderzeugung im Pflanzenreich, Braunschweig, 1828, 8vo. — BRAUN, (A.,) Ueber die Erscheinung der Verjüngung in der Natur, Freiburg, 1849, 4to. — MORTON, (S. G.,) Essay on Hybridity, Amer. Jour., 1847. — Additional Observations on Hybridity in Animals and on some collateral subjects, Charleston Med. Journ., 1850.

without entering here into a discussion respecting the possibility or practicability of setting aside this difficulty by introducing the consideration of the limited fertility of the progeny of individuals of different species, I will only remark, that as long as it is not proved that all the varieties of dogs, and of any others of our domesticated animals, and of our cultivated plants, are respectively derived from one unmixed species, and as long as doubts can be entertained respecting the common origin of all races of men from one common stock, it is not logical to admit that sexual connection resulting even in fertile offspring is a trustworthy evidence of specific identity.

To justify this assertion, I would only ask, where is the unprejudiced naturalist who in our days would dare to maintain: 1st, that it is proved that all the domesticated varieties of sheep, of goats, of bulls, of llamas, of horses, of dogs, of fowls, etc., are respectively derived from one common stock; 2d, that the supposition that these varieties have originated from the complete amalgamation of several primitively distinct species is out of the question; and 3d, that varieties imported from distant countries and not before brought together, such as the Shanghae fowl, for instance, do not completely mingle? Where is the physiologist who can conscientiously affirm that the limits of the fertility between distinct species are ascertained with sufficient accuracy to make it a test of specific identity? And who can say that the distinctive characters of fertile hybrids and of unmixed breeds are sufficiently obvious to enable anybody to point out the primitive features of all our domesticated animals, or of all our cultivated plants? As long as this cannot be done, as long as the common origin of all races of men, and of the different animals and plants mentioned above, is not proved, while their fertility with one another is a fact which has been daily demonstrated for thousands of years, as long as large numbers of animals are hermaphrodites, never requiring a connection with other individuals to multiply their species, as long as there are others which multiply in various ways without sexual intercourse, it is not justifiable to assume that those animals and plants are unmixed species, and that sexual fecundity is the criterion of specific identity. Moreover, this test can hardly ever have any practical value in most cases of the highest scientific interest. It is never resorted to, and, as far as I know, has never been applied with satisfactory results to settle any doubtful case. It has never assisted any anxious and conscientious naturalist in investigating the degree of relationship between closely allied animals or plants living in distant regions or in disconnected geographical areas. It will never contribute to the solution of any of those difficult cases of seeming difference or identity between extinct animals and plants found in different geological formations. In all critical cases, requiring the most minute accuracy and precision, it is discarded as unsafe, and of necessity questionable. Accurate science must do without it, and the sooner it is altogether discarded, the

better. But, like many relics of past time, it is dragged in as a sort of theoretical bugbear, and exhibited only now and then to make a false show in discussions upon the question of the unity of origin of mankind.

There is another fallacy connected with the prevailing ideas about species to which I would also allude: the fancy that species do not exist in the same way in nature as genera, families, orders, classes, and types. It is actually maintained by some that species are founded in nature in a manner different from these groups; that their existence is, as it were, more real, whilst that of the other groups is considered as ideal, even when it is admitted that these groups have themselves a natural foundation.

Let us consider this point more closely, as it involves the whole question of individuality. I wish, however, not to be understood as undervaluing the importance of sexual relations as indicative of the close ties which unite, or may unite, the individuals of the same species. I know as well as any one to what extent they manifest themselves in nature, but I mean to insist upon the undeniable fact that these relations are not so exclusive as those naturalists would represent them, who urge them as an unfailing criterion of specific identity. I would remind those who constantly forget it, that there are animals which, though specifically distinct do unite sexually, which do produce offspring, mostly sterile, it is true, in some species, but fertile to a limited extent in others, and in others even fertile to an extent which it has not yet been possible to determine. Sexual connection is the result, or rather one of the most striking expressions of the close relationship established in the beginning between individuals of the same species, and by no means the cause of their identity in successive generations. When first created, animals of the same species paired because they were made one for the other; they did not take one another in order to build up their species, which had full existence before the first individual produced by sexual connection was born.

This view of the subject acquires greater importance in proportion as it becomes more apparent that species did not originate in single pairs, but were created in large numbers, in those numeric proportions which constitute the natural harmonies between organized beings. It alone explains the possibility of the procreation of Hybrids, as founded upon the natural relationship of individuals of closely allied species, which may become fertile with one another, the more readily as they differ less, structurally.

To assume that sexual relations determine the species it should further be shown that absolute promiscuousness of sexes among individuals of the same species is the prevailing characteristic of the animal kingdom, while the fact is, that a large number even of animals, not to speak of Man, select their mate for life and rarely have any intercourse with others. It is a fact known to every farmer, that differ-

ent breeds of the same species are less inclined to mingle than individuals of the same breed. For my own part, I cannot conceive how moral philosophers, who urge the unity of origin of Man as one of the fundamental principles of their religion, can at the same time justify the necessity which it involves of a sexual intercourse between the nearest blood relations of that assumed first and unique human family, when such a connection is revolting even to the savage. Then again, there are innumerable species in which vast numbers of individuals are never developed sexually, others in which sexual individuals appear only now and then at remote intervals, while many intermediate generations are produced without any sexual connection, and others still which multiply more extensively by budding than by sexual generation. I need not again allude here to the phenomena of alternate generation, now so well known among Acalephs and Worms, nor to the polymorphism of many other types. Not to acknowledge the significance of such facts, would amount to the absurd pretension, that distinctions and definitions, introduced in our science during its infancy, are to be taken as standards for our appreciation of the phenomena in nature, instead of framing and remodelling our standards, according to the laws of nature, as our knowledge extends. It is, for instance, a specific character of the Horse and the Ass to be able to connect sexually with each other, and thus to produce an offspring different from that which they bring forth among themselves. It is characteristic of the Mare, as the representative of its species, to bring forth a Mule with the Jackass, and of the Stallion to procreate Hinnies with the She-ass. It is equally characteristic of them to produce still other kinds of halfbreeds with the Zebra, the Daw, etc. And yet in face of all these facts, which render sexual reproduction, or at least promiscuous intercourse among the representatives of the same species, so questionable a criterion of specific identity, there are still naturalists who would represent it as an unfailing test, only that they may sustain one single position, that all men are derived from one single pair.

These facts, with other facts which go to show more extensively every day the great probability of the independent origin of individuals of the same species in disconnected geographical areas, force us to remove from the philosophic definition of species the idea of a community of origin, and consequently, also, the idea of a necessary genealogical connection. The evidence that all animals have originated in large numbers is growing so strong, that the idea that every species existed in the beginning in single pairs, may be said to be given up almost entirely by naturalists. Now if this is the case, sexual derivation does not constitute a necessary specific character, even though sexual connection be the natural process of their reproduction and multiplication. If we are led to admit as the beginning of each species, the simultaneous origin of a large number of individuals, if the same

species may originate at the same time in different localities, these first representatives of each species, at least, were not connected by sexual derivation; and as this applies equally to any first pair, this fancied test criterion of specific identity must at all events be given up, and with it goes also the pretended real existence of the species, in contradistinction from the mode of existence of genera, families, orders, classes, and types; for what really exists are individuals, not species. We may at the utmost consider individuals as representatives of species, but no one individual nor any number of individuals represent its species only, without representing also at the same time, as we have seen above (Sect. I. to V.), its genus, its family, its order, its class, its type.

Before attempting to prove the whole of this proposition, I will first consider the characters of the individual animals. Their existence is scarcely limited as to time and space within definite and appreciable limits. No one nor all of them represent fully, at any particular time, their species; they are always only the temporary representatives of the species, inasmuch as each species exists longer in nature than any of its individuals. All the individuals of any or of all species now existing are only the successors of other individuals which have gone before, and the predecessors of the next generations; they do not constitute the species, they represent it. The species is an ideal entity, as much as the genus, the family, the order, the class, or the type; it continues to exist, while its representatives die, generation after generation. But these representatives do not simply represent what is specific in the individual, they exhibit and reproduce in the same manner, generation after generation, all that is generic in them, all that characterizes the family, the order, the class, the branch, with the same fulness, the same constancy, the same precision. Species then exist in nature in the same manner as any other groups, they are quite as ideal in their mode of existence as genera, families, etc., or quite as real. But individuals truly exist in a different way; no one of them exhibits at one time all the characteristics of the species, even though it be hermaphrodite, neither do any two represent it, even though the species be not polymorphous, for individuals have a growth, a youth, a mature age, an old age, and are bound to some limited home during their lifetime. It is true species are also limited in their existence; but for our purpose, we can consider these limits as boundless, inasmuch as we have no means of fixing their duration, either for the past geological ages, or for the present period, whilst the short cycles of the life of individuals are easily measurable quantities. Now as truly as individuals, while they exist, represent their species for the time being, and do not constitute them, so truly do these same individuals represent at the same time their genus, their family, their order, their class, and their type, the characters of which they bear as indelibly as those of the species.

As representatives of Species, individual animals bear the closest relations to one another; they exhibit definite relations also to the surrounding elements, and their existence is limited within a definite period.

As representatives of Genera, these same individuals have a definite and specific ultimate structure, identical with that of the representatives of other species.

As representatives of Families, these same individuals have a definite figure exhibiting, with similar forms of other genera, or for themselves, if the family contains but one genus, a distinct specific pattern.

As representatives of Orders, these same individuals stand in a definite rank when compared to the representatives of other families.

As representatives of Classes, these same individuals exhibit the plan of structure of their respective type in a special manner, carried out with special means and in special ways.

As representatives of Branches, these same individuals are all organized upon a distinct plan, differing from the plan of other types.

Individuals then are the bearers, for the time being, not only of specific characteristics, but of all the natural features in which animal life is displayed in all its diversity.

Viewing individuals in this light, they resume all their dignity; they are no longer absorbed in the species to be for ever its representatives, without ever being any thing for themselves. On the contrary, it becomes plain, from this point of view, that the individual is the worthy bearer, for the time being, of all the riches of nature's wealth of life. This view further teaches us how we may investigate, not only the species in the individual, but the genus also, the family, the order, the class, the type, as indeed naturalists have at all times proved in practice, whilst denying the possibility of it in theory.

Having thus cleared the field of what does not belong therein, it now remains for me to show what in reality constitutes species, and how they may be distinguished with precision within their natural limits.

If we would not exclude from the characteristics of species any feature which is essential to it, nor force into it any one which is not so, we must first acknowledge that it is one of the characters of species to belong to a given period in the history of our globe, and to hold definite relations to the physical conditions then prevailing, and to animals and plants then existing. These relations are manifold, and are exhibited: 1st, in the geographical range natural to any species, as well as in its capability of being acclimated in countries where it is not primitively found; 2d, in the connection in which they stand to the elements around them, when they inhabit either the water, or the land, deep seas, brooks, rivers and lakes, shoals, flat, sandy, muddy, or rocky coasts, limestone banks, coral reefs, swamps,

meadows, fields, dry lands, salt deserts, sandy deserts, moist land, forests, shady groves, sunny hills, low regions, plains, prairies, high table-lands, mountain peaks, or the frozen barrens of the Arctics, etc.; 3d, in their dependence upon this or that kind of food for their sustenance; 4th, in the duration of their life; 5th, in the mode of their association with one another, whether living in flocks, small companies, or isolated; 6th, in the period of their reproduction; 7th, in the changes they undergo during their growth, and the periodicity of these changes in their metamorphosis; 8th, in their association with other beings, which is more or less close, as it may only lead to a constant association in some, whilst in others it amounts to parasitism; 9th, specific characteristics are further exhibited in the size animals attain, in the proportions of their parts to one another, in their ornamentation, etc., and all the variations to which they are liable.

As soon as all the facts bearing upon these different points have been fully ascertained, there can remain no doubt respecting the natural limitation of species; and it is only the insatiable desire of describing new species from insufficient data which has led to the introduction in our systems of so many doubtful species, which add nothing to our real knowledge, and only go to swell the nomenclature of animals and plants already so intricate.

Assuming then, that species cannot always be identified at first sight, that it may require a long time and patient investigations to ascertain their natural limits; assuming further, that the features alluded to above are among the most prominent characteristics of species, we may say, that species are based upon well determined relations of individuals to the world around them, to their kindred, and upon the proportions and relations of their parts to one another, as well as upon their ornamentation. Well digested descriptions of species ought, therefore, to be comparative; they ought to assume the character of biographies, and attempt to trace the origin and follow the development of a species during its whole existence. Moreover, all the changes which species may undergo in course of time, especially under the fostering care of man, in the state of domesticity and cultivation, belong to the history of the species; even the anomalies and diseases to which they are subject, belong to their cycle, as well as their natural variations. Among some species, variation of color is frequent, others never change, some change periodically, others accidentally; some throw off certain ornamental appendages at regular times, the Deers their horns, some Birds the ornamental plumage they wear in the breeding season, etc. All this should be ascertained for each, and no species can be considered as well defined and satisfactorily characterized, the whole history of which is not completed to the extent alluded to above. The practice prevailing since Linnæus of limiting the characteristics of species to mere diagnoses, has led to the present confusion of our nomenclature, and made it often impossible to

ascertain what were the species the authors of such condensed descriptions had before them. But for the tradition which has transmitted, generation after generation, the knowledge of these species among the cultivators of science in Europe, this confusion would be still greater; but for the preservation of most original collections it would be inextricable. In countries, which, like America, do not enjoy these advantages, it is often hopeless to attempt critical investigations upon doubtful cases of this kind. One of our ablest and most critical investigators, the lamented Dr. Harris, has very forcibly set forth the difficulties under which American naturalists labor in this respect, in the Preface to his Report upon the Insects Injurious to Vegetation.

SECTION VII.

OTHER NATURAL DIVISIONS AMONG ANIMALS.

Thus far I have considered only those kinds of divisions which are introduced in almost all our modern classifications, and attempted to show that these groups are founded in nature and ought not to be considered as artificial devices, invented by man to facilitate his studies. Upon the closest scrutiny of the subject, I find that these divisions cover all the categories of relationship which exist among animals, as far as their structure is concerned.

Branches or *types* are characterized by the plan of their structure,

Classes, by the manner in which that plan is executed, as far as ways and means are concerned,

Orders, by the degrees of complication of that structure,

Families, by their form, as far as determined by structure,

Genera, by the details of the execution in special parts, and

Species, by the relations of individuals to one another and to the world in which they live, as well as by the proportions of their parts, their ornamentation, etc.

And yet there are other natural divisions which must be acknowledged in a natural zoölogical system; but these are not to be traced so uniformly in all classes as the former, — they are in reality only limitations of the other kinds of divisions.

A class in which one system of organs may present a peculiar development, while all the other systems coincide, may be subdivided into sub-classes; for instance, the Marsupialia when contrasted with the Placental Mammalia. The characters

upon which such a subdivision is founded, are of the kind upon which the class itself is based, but do not extend to the whole class. An order may embrace natural groups, of a higher value than families, founded upon ordinal characters, which may yet not determine absolute superiority or inferiority, and therefore not constitute for themselves distinct orders; as the characters upon which they are founded, though of the kind which determines orders, may be so blended as to determine superiority in one respect, while with reference to some other features they may indicate inferiority. Such groups are called sub-orders. The order of Testudinata, which I shall consider more in detail in the second part of this volume, may best illustrate this point, as it contains two natural sub-orders. A natural family may exhibit such modifications of its characteristic form, that upon these modifications subdivisions may be distinguished, which have been called sub-families by some authors, tribes or legions by others. In a natural genus, a number of species may agree more closely than others in the particulars which constitute the genus and lead to the distinction of sub-genera. The individuals of a species, occupying distinct fields of its natural geographical area, may differ somewhat from one another, and constitute varieties, etc.

These distinctions have long ago been introduced into our systems, and every practical naturalist, who has made a special study of any class of the animal kingdom, must have been impressed with the propriety of acknowledging a large number of subdivisions, to express all the various degrees of affinity of the different members of any higher natural group. Now, while I maintain that the branches, the classes, the orders, the families, the genera, and the species are groups established in nature respectively upon different categories, and while I feel prepared to trace the natural limits of these groups by the characteristic features upon which they are founded, I must confess at the same time that I have not yet been able to discover the principle which obtains in the limitation of their respective subdivisions. All I can say is, that all the different categories considered above, upon which branches, classes, orders, families, genera, and species are founded, have their degrees, and upon these degrees sub-classes, sub-orders, sub-families, and sub-genera have been established. For the present, these subdivisions must be left to arbitrary estimations, and we shall have to deal with them as well as we can, as long as the principles which regulate these degrees in the different kinds of groups are not ascertained. I hope, nevertheless, that such arbitrary estimations are for ever removed from our science, as far as the categories themselves are concerned.

Thus far, inequality of weight seems to be the standard of the internal valuation of each kind of group; and this inequality extends to all groups, for even within the branches there are classes more closely related among themselves than others: Polypi and Acalephs, for instance, stand nearer to one another than

to Echinoderms; Crustacea and Insects are more closely allied to one another than to Worms, etc. Upon such degrees of relationship between the classes, within their respective branches, the so-called sub-types have been founded, and these differences have occasionally been exaggerated so far as to give rise to the establishment of distinct branches. Upon similar relations between the branches, sub-kingdoms have also been distinguished, but I hardly think that such far-fetched combinations can be considered as natural groups; they seem to me rather the expression of a relation arising from the weight of their whole organization, as compared with that of other groups, than the expression of a definite relationship.

SECTION VIII.

SUCCESSIVE DEVELOPMENT OF CHARACTERS.

It has been repeated, again and again, that the characters distinguishing the different types of the animal kingdom were developed in the embryo in the successive order of their importance: first the structural features of their respective branches, next the characters of the class, next those of the order, next those of the family, next those of the genus, and finally those of the species. This assertion has met with no direct opposition; on the contrary, it seems to have been approved almost without discussion, and to be generally taken for granted now. The importance of the subject requires, however, a closer scrutiny; for if Embryology is to lead to great improvements in Zoölogy, it is necessary, at the outset, to determine well what kind of information we may expect it to furnish to its sister science. Now I would ask if, at this day, zoölogists know with sufficient precision what are typical, class, ordinal, family, generic, and specific characters, to be justified in maintaining that, in the progress of embryonic growth, the features which become successively prominent correspond to these characters and in the order of their subordination? I doubt it. I will say more: I am sure there is no such understanding about it among them, for if there was, they would already have perceived that this assumed coincidence, between the subordination of natural groups among full-grown animals and the successive stages of growth during their embryonic period of life, does not exist in nature. It is true, there are certain features in the embryonic development which may suggest the idea of a progress from a more general typical organization to its ultimate specialization, but it nowhere proceeds in that stereotyped order of succession, nor indeed even in a general way, in the manner thus assumed.

Let us see whether it is not possible to introduce more precision in this matter. Taking for granted that what I have said about the characteristics of the natural groups in the animal kingdom is correct, that we have, 1st, four great typical branches of the animal kingdom, characterized by different plans of structure; 2d, classes, characterized by the ways in which and the means with which these plans of structure are executed; 3d, orders, characterized by the degrees of simplicity or complication of that structure; 4th, families, characterized by differences of form, or by the structural peculiarities determining form; 5th, genera, characterized by ultimate peculiarities of structure in the parts of the body; 6th, species, characterized by relations and proportions of parts among themselves, and of the individuals to one another and to the surrounding mediums; we reach, finally, the individuals, which, for the time being, represent not only the species with all their varieties, and variations of age, sex, size, etc., but also the characteristic features of all the higher groups. We have thus, at one end of the series, the most comprehensive categories of the structure of animals, while at the other end we meet individual beings. Individuality on one side, the most extensive divisions of the animal kingdom on the other. Now, to begin our critical examination of the progress of life in its successive manifestations with the extremes, is it not plain, from all we know of Embryology, that individualization is the first requirement of all reproduction and multiplication, and that an individual germ, (or a number of them,) an ovarian egg, or a bud, is first formed and becomes distinct as an individual from the body of the parent, before it assumes either the characters of its great type or those of its class, order, etc.? This fact is of great significance, as showing the importance of individuality in nature. Next, it is true, we perceive generally the outlines of the plan of structure, before it becomes apparent in what manner that plan is to be carried out; the character of the type is marked out, in its most general features, before that of the class can be recognized with any degree of precision. Upon this fact, we may base one of the most important generalizations in Embryology.

It has been maintained, in the most general terms, that the higher animals pass during their development through all the phases characteristic of the inferior classes. Put in this form, no statement can be further from the truth, and yet there are decided relations within certain limits, between the embryonic stages of growth of higher animals and the permanent characters of others of an inferior grade. Now the fact mentioned above, enables us to mark with precision the limits within which these relations may be traced. As eggs, in their primitive condition, animals do not differ one from the other; but as soon as the embryo has begun to show any characteristic features, it presents such peculiarities as distinguish its type. It cannot, therefore, be said that any animal passes through

phases of development, which are not included within the limits of its own type; no Vertebrate is, or resembles, at any time an Articulate, no Articulate a Mollusk, no Mollusk a Radiate, and *vice versâ*. Whatever correlations between the young of higher animals and the perfect condition of inferior ones may be traced, they are always limited to representatives of the same great types; for instance, Mammalia and Birds, in their earlier development, exhibit certain features of the lower classes of Vertebrates, such as the Reptiles or Fishes; Insects recall the Worms in some of their earlier stages of growth, etc., but even this requires qualifications to which we shall have to refer hereafter. However, thus much is already evident, that no higher animal passes through phases of development recalling all the lower types of the animal kingdom, but only such as belong to its own branch. What has been said of the infusorial character of young embryos of Worms, Mollusks, and Radiates, can no longer stand before a serious criticism, because, in the first place, the animals generally called Infusoria cannot themselves be considered as a natural class; and in the second place, those to which a reference is made in this connection, are themselves free-moving embryos.[1]

With the progress of growth and in proportion as the type of an animal becomes more distinctly marked, in its embryonic state, the plan of structure appears also more distinctly in the peculiarities of that structure, that is to say, in the ways in which and the means by which the plan, only faintly indicated at first, is to be carried out and become prominent, and by this the class character is pointed out. For instance, a wormlike insect larva will already show, by its tracheæ, that it is to be an Insect and not to remain a Worm, as it at first appears to be; but the complications of that special structure, upon which the orders of the class of Insects are based, do not yet appear; this is perfected only at a late period in the embryonic life. At this stage, we frequently notice already a remarkable advance of the features characteristic of the families over those characteristic of the order; for instance, young Hemiptera, young Orthoptera may safely be referred to their respective families, from the characteristics they exhibit before they show those peculiarities which characterize them as Hemiptera or as Orthoptera; young Fishes may be known as members of their respective families before the characters of their orders are apparent, etc.

It is very obvious why this should be so. With the progress of the development of the structure, the general form is gradually sketched out, and it has already reached many of its most distinctive features, before all the complications of the structure which characterize the orders have become apparent; and as form characterizes essentially the families, we see here the reason why the family type

[1] See above, Chap. I., Sect. 18, p. 75.

may be fully stamped upon an animal before its ordinal characters are developed. Even specific characters, as far as they depend upon the proportions of parts and have on that ground an influence in modifying the form, may be recognized long before the ordinal characters are fully developed. The Snapping-Turtle, for instance, exhibits its small crosslike sternum, its long tail, its ferocious habits even before it leaves the egg, before it breathes through lungs, before its derm is ossified to form a bony shield, etc.; nay, it snaps with its gaping jaws at any thing brought near, though it be still surrounded by its amnios and allantois, and its yolk still exceeds in bulk its whole body.[1] The calf assumes the form of the bull before it bears the characteristics of the hollow-horned Ruminants; the fawn exhibits all the peculiarities of its species before those of its family are unfolded.

With reference to generic characters, it may be said that they are scarcely ever developed in any type of the animal kingdom, before the specific features are for the most part fully sketched out, if not completely developed. Can there be any doubt that the human embryo belongs to the genus Homo, even before it has cut a tooth? Is not a kitten, or a puppy distinguishable as a cat or a dog, before the claws and teeth tell their genus? Is this not true also of the Lamb, the Kid, the Colt, the Rabbits, and the Mice, of most Birds, most Reptiles, most Fishes, most Insects, Mollusks and Radiates? And why should this be? Simply, because the proportions of parts, which constitute specific characters, are recognizable before their ultimate structural development, which characterizes genera, is completed.

It seems to me that these facts are likely to influence the future progress of Zoölogy, in enabling us gradually to unravel more and more distinctly, the features which characterize the different subordinate groups of the animal kingdom. The views I have expressed above of the respective value and the prominent characteristics of these different groups, have stood so completely the test in this analysis of their successive appearance, that I consider this circumstance as adding to the probability of their correctness.

But this has another very important bearing, to which I have already alluded in the beginning of these remarks. Before Embryology can furnish the means of settling some of the most perplexing problems in Zoölogy, it is indispensable to ascertain first what are typical, classic, ordinal, family, generic, and specific characters; and as long as it could be supposed that these characters appear necessarily

[1] PR. M. v. NEU-WIED quotes as a remarkable fact, that the Chelonara serpentina bites as soon as it is hatched. I have seen it snapping in the same fierce manner as it does when full-grown, at a time it was still a pale, almost colorless embryo, wrapped up in its fœtal envelopes, with a yolk larger than itself hanging from its sternum, three months before hatching.

during the embryonic growth, in the order of their subordination, there was no possibility of deriving from embryological monographs, that information upon this point, so much needed in Zoölogy, and so seldom alluded to by embryologists. Again, without knowing what constitutes truly the characters of the groups named above, there is no possibility of finding out the true characters of a genus of which only one species is known, of a family which contains only one genus, etc., and for the same reason no possibility of arriving at congruent results with reference to the natural limitations of genera, families, orders, etc., without which we cannot even begin to build up a permanent classification of the animal kingdom; and still less, hope to establish a solid basis for a general comparison between the animals now living and those which have peopled the surface of our globe in past geological ages.

It is not accidentally I have been led to these investigations, but by necessity. As often as I tried to compare higher or more limited groups of animals of the present period with those of former ages, or early stages of growth of higher living animals with full-grown ones of lower types, I was constantly stopped in my progress by doubts as to the equality of the standards I was applying, until I made the standards themselves the object of direct and very extensive investigations, covering indeed a much wider ground than would appear from these remarks, for, upon these principles, I have already remodelled, for my own convenience, nearly the whole animal kingdom, and introduced in almost every class very unexpected changes in the classification.

I have already expressed above[1] my conviction that the only true system is that which exists in nature, and as, therefore, no one should have the ambition of erecting a system of his own, I will not even attempt now to present these results in the shape of a diagram, but remain satisfied to express my belief, that all we can really do is, at best, to offer imperfect translations in human language of the profound thoughts, the innumerable relations, the unfathomable meaning of the plan actually manifested in the natural objects themselves; and I should consider it as my highest reward should I find, after a number of years, that I had helped others on in the right path.

[1] See Chap. I., Sect. 1, p. 7–9.

SECTION IX.

CONCLUSIONS.

The importance of such an investigation as the preceding, must be obvious to every philosophical investigator. As soon as it is understood that all the different groups introduced into a natural system may have a definite meaning; as soon as it can be shown that each exhibits a definite relation among living beings, founded in nature, and no more subject to arbitrary modifications than any other law expressing natural phenomena; as soon as it is made plain that the natural limits of all these groups may be ascertained by careful investigations, the interest in the study of classification or the systematic relationship existing among all organized beings, which has almost ceased to engage the attention of the more careful original investigators, will be revived, and the manifold ties which link together all animals and plants, as the living expression of a gigantic conception, carried out in the course of time, like a soul-breathing epos, will be scrutinized anew, determined with greater precision, and expressed with increasing clearness and propriety. Fanciful and artificial classifications will gradually lose their hold upon a better informed community; scientific men themselves will be restrained from bringing forward immature and premature investigations; no characteristics of new species will have a claim upon the notice of the learned, which has not been fully investigated and compared with those most closely allied to it; no genus will be admitted, the structural peculiarities of which are not clearly and distinctly illustrated; no family will be considered as well founded, which shall not exhibit a distinct system of forms intimately combined and determined by structural relations; no order will appear admissible, which shall not represent a well-marked degree of structural complication; no class will deserve that name, which shall not appear as a distinct and independent expression of some general plan of structure, carried out in a peculiar way and with peculiar means; no type will be recognized as one of the fundamental groups of the animal kingdom, which shall not exhibit a plan of its own, not convertible into another. No naturalist will be justified in introducing any one of these groups into our systems without showing: 1st, that it is a natural group; 2d, that it is a group of this or that kind, to avoid, henceforth, calling families groups that may be genera, families groups that may be orders, classes or types groups that may be orders or classes; 3d, that the characters by which these groups may be recognized are in fact respectively specific,

generic, family, ordinal, classic, or typical characters, so that our works shall no longer exhibit the annoying confusion, which is to be met almost everywhere, of generic characters in the diagnoses of species, or of family and ordinal characters in the characteristics of classes and types.[1]

It may perhaps be said, that all this will not render the study of Zoölogy more easy. I do not expect that it will; but if an attentive consideration of what I have stated in the preceding pages respecting classification, should lead to a more accurate investigation of all the different relations existing among animals, and between them and the world in which they live, I shall consider myself as having fully succeeded in the object I have had in view from the beginning, in this inquiry. Moreover, it is high time that certain zoölogists, who would call themselves investigators, should remember, that natural objects, to be fully understood, require more than a passing glance; they should imitate the example of astronomers, who have not become tired of looking into the relations of the few members of our solar system to determine, with increased precision, their motions, their size, their physical constitution, and keep in mind that every organized being, however simple in its structure, presents to our appreciation far more complicated phenomena, within our reach, than all the celestial bodies put together; they should remember, that as the great literary productions of past ages attract ever anew the attention of scholars, who can never feel that they have exhausted the inquiry into their depth and beauty, so the living works of God, which it is the proper sphere of Zoölogy to study, would never cease to present new attractions to them, should they proceed to the investigation with the right spirit. Their studies ought, indeed, inspire every one with due reverence and admiration for such wonderful productions.

The subject of classification in particular, which seems to embrace apparently so limited a field in the science of animals, cannot be rightly and fully understood without a comprehensive knowledge of all the topics alluded to in the preceding pages.

[1] As I do not wish to be personal, I will refrain from quoting examples to justify this assertion. I would only request those who care to be accurate, to examine critically almost any description of species, any characterization of genera, of families, of orders, of classes, and of types, to satisfy themselves that characters of the same kind are introduced almost indiscriminately to distinguish all these groups.

CHAPTER THIRD.

NOTICE OF THE PRINCIPAL SYSTEMS OF ZOÖLOGY.

SECTION I.

GENERAL REMARKS UPON MODERN SYSTEMS.

Without attempting to give an historical account of the leading features of all zoölogical systems, it is proper that I should here compare critically the practice of modern naturalists with the principles discussed above. With this view, it would hardly be necessary to go back beyond the publication of the "Animal Kingdom," by Cuvier, were it not that Cuvier is still represented, by many naturalists, and especially by Ehrenberg,[1] and some other German zoölogists, as favoring the division of the whole animal kingdom into two great groups, one containing the Vertebrates, and the other all the remaining classes, under the name of Invertebrates, while in reality it was he, who first, dismissing his own earlier views, introduced into the classification of the animal kingdom that fourfold division which has been the basis of all improvements in modern Zoölogy. He first showed that animals differ, not only by modifications of one and the same organic structure, but are constructed upon four different plans of structure, forming natural, distinct groups, which he called Radiata, Articulata, Mollusca, and Vertebrata.

It is true, that the further subdivisions of these leading groups have undergone many changes since the publication of the "Règne Animal." Many smaller groups, even entire classes, have been removed from one of his "embranchments" to another; but it is equally true, that the characteristic idea which lies at the bottom of these great divisions was first recognized by him, the greatest zoölogist of all times.

[1] Ehrenberg, (C. G.,) Die Corallenthiere des rothen Meeres, Berlin, 1834, 4to., p. 30.

The question which I would examine here in particular, is not whether the circumscription of these great groups was accurately defined by Cuvier, whether the minor groups referred to them truly belong there or elsewhere, nor how far these divisions may be improved within their respective limits, but whether there are four great fundamental groups in the animal kingdom, based upon four different plans of structure, and neither more nor less than four. This question is very seasonable, since modern zoölogists, and especially Siebold, Leuckart, and Vogt have proposed combinations of the classes of the animal kingdom into higher groups, differing essentially from those of Cuvier. It is but justice to Leuckart to say that he has exhibited, in the discussion of this subject, an acquaintance with the whole range of Invertebrata,[1] which demands a careful consideration of the changes he proposes, as they are based upon a critical discrimination of differences of great value, though I think he overrates their importance. The modifications introduced by Vogt, on the contrary, appear to me to be based upon entirely unphysiological principles, though seemingly borrowed from that all important guide, Embryology.

The divisions adopted by Leuckart are: Protozoa, (though he does not enter upon an elaborate consideration of that group,) Coelenterata, Echinodermata, Vermes, Arthropoda, Mollusca, and Vertebrata. The classification adopted, many years before, by Siebold, in his text-book of comparative anatomy, is nearly the same, except that Mollusks follow the Worms, that Coelenterata and Echinoderms are united into one group, and that the Bryozoa are left among the Polyps.

Here we have a real improvement upon the classification of Cuvier, inasmuch as the Worms are removed from among the Radiates, and brought nearer the Arthropods, an improvement however, which, so far as it is correct, has already been anticipated by many naturalists, since Blainville and other zoölogists long ago felt the impropriety of allowing them to remain among Radiates, and have been induced to associate them more or less closely with Articulates. But I believe the union of Bryozoa and Rotifera with the Worms, proposed by Leuckart, to be a great mistake; as to the separation of Coelenterata from Echinoderms, I consider it as an exaggeration of the difference which exists between Polyps and Acalephs on the one hand, and Echinoderms on the other.

The fundamental groups adopted by Vogt,[2] are: Protozoa, Radiata, Vermes, Mollusca, Cephalopoda, Articulata, and Vertebrata, an arrangement which is based solely upon the relations of the embryo to the yolk, or the absence of eggs. But, as

[1] LEUCKART, (R.,) Ueber die Morphologie und die Verwandtshaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 1 vol., 8vo.

[2] VOGT, (CARL,) Zoologische Briefe. Naturgeschichte der lebenden und untergegangenen Thiere. Frankfurt a. M., 1851; vol. 1, p. 70.

I have already stated, this is an entirely unphysiological principle, inasmuch as it assumes a contrast between the yolk and the embryo, within limits which do not exist in nature. The Mammalia, for instance, which are placed, like all other Vertebrata, in the category of the animals in which there is an opposition between the embryo and the yolk, are as much formed of the whole yolk as the Echinoderms or Mollusks. The yolk undergoes a complete segmentation in Mammalia, as well as in Radiates or Worms, and most Mollusks; and the embryo when it makes its appearance no more stands out from the yolk, than the little Starfish stands out from its yolk. These simple facts, known since Sars and Bischoff published their first observations, twenty years ago, is in itself sufficient to show that the whole principle of classification of Vogt is radically wrong.

Respecting the assertion, that neither Infusoria nor Rhizopoda produce any eggs, I shall have more to say presently. As to the arrangement of the leading groups, Vertebrata, Articulata, Cephalopoda, Mollusca, Vermes, Radiata, and Protozoa in Vogt's system, it must be apparent to every zoölogist conversant with the natural affinities of animals, that a classification which interposes the whole series of Mollusks between the types of Articulata and Worms, cannot be correct. A classification based, like this, solely upon the changes which the yolk undergoes, is not likely to be the natural expression of the manifold relations existing between all animals. Indeed, no system can be true to nature, which is based upon the consideration of a single part, or a single organ.

After these general remarks, I have only to show more in detail, why I believe that there are only four great fundamental groups in the animal kingdom, neither more nor less.

With reference to Protozoa, first, it must be acknowledged that, notwithstanding the extensive investigation of modern writers upon Infusoria and Rhizopoda, the true nature of these beings is still very little known. The Rhizopoda have been wandering from one end of the series of Invertebrata to the other, without finding a place generally acknowledged as expressing their true affinities. The attempt to separate them from all the classes with which they have been so long associated, and to place them with the Infusoria in one distinct branch, appears to me as mistaken as any of the former arrangements, for I do not even consider that their animal nature is yet proved beyond a doubt, though I have myself once suggested the possibility of a definite relation between them and the lowest Gasteropods. Since it has been satisfactorily ascertained that the Corallines are genuine Algæ, which contain more or less lime in their structure, and since there is hardly any group among the lower animals and lower plants, which does not contain simple locomotive individuals, as well as compound communities, either free or adhering to the soil, I do not see that the facts known at present preclude the possibility

of an association of the Rhizopods with the Algæ.[1] This would almost seem natural, when we consider that the vesicles of many Fuci contain a viscid, filamentous substance, so similar to that protruded from the body of the Rhizopods, that the most careful microscopic examination does not disclose the slightest difference in its structure from that which mainly forms the body of Rhizopods. The discovery by Schultze[2] of what he considers as the germinal granules of these beings, by no means settles this question, though we have similar ovoid masses in Algæ, and though, among the latter, locomotive forms are also very numerous.

With reference to the Infusoria, I have long since expressed my conviction that they are an unnatural combination of the most heterogeneous beings. A large number of them, the Desmidieæ and Volvocinæ, are locomotive Algæ. Indeed, recent investigations seem to have established beyond all question, the fact, that all the Infusoria Anentera of Ehrenberg are Algæ. The Enterodela, however, are true animals, but belong to two very distinct types, for the Vorticellidæ differ entirely from all others. Indeed, they are, in my opinion, the only independent animals of that group, and so far from having any natural affinity with the other Enterodela, I do not doubt that their true place is by the side of Bryozoa, among Mollusks, as I shall attempt to show presently. Isolated observations which I have been able to make upon Paramecium, Opalina, and the like, seem to me sufficient to justify the assumption that they disclose the true nature of the bulk of this group. I have seen, for instance, a Planaria lay eggs out of which Paramecium were born, which underwent all the changes these animals are known to undergo up to the time of their contraction into a chrysalis state; while the Opalina is hatched from Distoma eggs. I shall publish the details of these observations on another occasion. But if it can be shown that two such types as Paramecium and Opalina are the progeny of Worms, it seems to me to follow, that all the Enterodela, with the exception of the Vorticellidæ, must be considered as the embryonic condition of that host of Worms, both parasitic and free, the metamorphosis of which is still unstudied. In this connection, I might further remark, that the time is not long past when Cercaria was also considered as belonging to the class of Infusoria, though at present no one doubts that it belongs to the cycle of Distoma; and the only link in the metamorphosis of that genus which was not known is now supplied, since, as I have stated above, the embryo which is hatched from the egg laid by the perfect Distoma is found to be Opalina.

All this leads to the conclusion, that a division of the animal kingdom to be called Protozoa, differing from all other animals in producing no eggs, does not exist in nature, and that the beings which have been referred to it have now

[1] Comp. Chap. I., Sect. 18, p. 75.

[2] SCHULTZE, (M. S.,) Polythalamien, q. a.; p. 24.

to be divided, and scattered, partly among plants, in the class of Algæ, and partly among animals, in the classes of Acephala, (Vorticellæ,) of Worms, (Paramecium and Opalina,) and of Crustacea (Rotifera); Vorticellæ being genuine Bryozoa and therefore Acephalous Mollusks, while the beautiful investigations of Dana and Leydig have proved the Rotifera to be genuine Crustacea, and not Worms.

The great type of Radiata, taking its leading features only, was first recognized by Cuvier, though he associated with it many animals which do not properly belong to it. This arose partly from the imperfect knowledge of those animals at the time, but partly also from the fact that he allowed himself, in this instance, to deviate from his own principle of classification, according to which types are founded upon special plans of structure. With reference to Radiata, he departed, indeed, from this view, so far as to admit, besides the consideration of their peculiar plan, the element of simplicity of their structure as an essential feature in the typical character of these animals, in consequence of which he introduced five classes among Radiata: the Echinoderms, Intestinal Worms, Acalephs, Polypi, and Infusoria. In opposition to this unnatural association, I need not repeat here, what I have already stated of the Infusoria, when considering the case of Protozoa; neither is it necessary to urge again the propriety of removing the Worms from among Radiata, and connecting them with Articulata. There would thus remain only three classes among Radiates, — Polypi, Acalephs, and Echinoderms, — which, in my opinion, constitute really three natural classes in this great division, inasmuch as they exhibit the three different ways in which the characteristic plan of the type, radiation, is carried out, in distinct structures.

Since it can be shown that Echinoderms are, in a general way, homologous in their structure with Acalephs and Polypi, it must be admitted that these classes belong to one and the same great type, and that they are the only representatives of the branch of Radiata, assuming of course that Bryozoa, Corallinæ, Sponges, and all other foreign admixtures have been removed from among Polyps. Now, it is this Cuvierian type of Radiata, thus freed of all its heterogeneous elements, which Leuckart undertakes to divide into two branches, each of which he considers coequal with Worms, Articulates, Mollusks, and Vertebrates. He was undoubtedly led to this exaggeration of the difference existing between Echinoderms on one side and Acalephs and Polypi on the other, by the apparently greater resemblance of Medusæ and Polypi,[1] and perhaps still more by the fact, that so many genuine Acalephs, such as the Hydroids, including Tubularia, Sertularia, Campanularia, etc., are still comprised by most zoölogists in the class of Polypi.

[1] We see here clearly how the consideration of anatomical differences which characterize classes has overridden the primary feature of branches, their plan, to exalt a class to the rank of a branch.

But since the admirable investigations of J. Müller have made us familiar with the extraordinary metamorphosis of Echinoderms, and since the Ctenophoræ and the Siphonophoræ have also been more carefully studied by Grube, Leuckart, Kölliker, Vogt, Gegenbaur, and myself, the distance which seemed to separate Echinoderms from Acalephs disappears entirely, for it is no exaggeration to say, that were the Pluteus-like forms of Echinoderms not known to be an early stage in the transformation of Echinoderms, they would find as natural a place among Ctenophoræ, as the larvæ of Insects among Worms. I therefore maintain, that Polypi, Acalephs, and Echinoderms constitute one indivisible primary group of the animal kingdom. The Polypoid character of young Medusæ proves this as plainly as the Medusoid character of young Echinoderms.

Further, nothing can be more unnatural than the transfer of Ctenophoræ to the type of Mollusks which Vogt has proposed, for Ctenophoræ exhibit the closest homology with the other Medusæ, as I have shown in my paper on the Beroid Medusæ of Massachusetts. The Ctenophoroid character of young Echinoderms establishes a second connection between Ctenophoræ and the other Radiata, of as great importance as the first. We have thus an anatomical link to connect the Ctenophoræ with the genuine Medusæ, and an embryological link to connect them with the Echinoderms.

The classification of Radiata may, therefore, stand thus:—

1st Class: Polypi; including two orders, the Actinoids and the Halcycnoids, as limited by Dana.

2d Class: Acalephae; with the following orders: Hydroids, (including Siphonophoræ,) Discophoræ, and Ctenophoræ.

3d Class: Echinoderms; with Crinoids, Asteroids, Echinoids, and Holothurioids, as orders.

The natural limits of the branch of Mollusks are easily determined. Since the Cirripeds have been removed to the branch of Articulata, naturalists have generally agreed to consider, with Cuvier, the Cephalopods, Pteropods, Gasteropods, and Acephala as forming the bulk of this type, and the discrepancies between modern investigators have mainly resulted from the views they have taken respecting the Bryozoa, which some consider still as Polyps, while others would unite them with the Worms, though their affinity with the Mollusks seems to me to have been clearly demonstrated by the investigations of Milne-Edwards. Vogt is the only naturalist who considers the Cephalopoda "as built upon a plan entirely peculiar;[1] though he does not show in what this peculiarity of plan consists, but only mentions the well-known anatomical differences which distinguish them from the other classes

[1] VOGT, (C.,) Zoologische Briefe, q. a.; vol. 1, p. 361.

of the branch of Mollusks. These differences, however, constitute only class characters and exhibit in no way a different plan. It is, indeed, by no means difficult to homologize all the systems of organs of the Cephalopods with those of the other Mollusks, and with this evidence, the proof is also furnished that the Cephalopods constitute only a class among the Mollusks.

As to the differences in the development of the Cephalopods and the other Mollusks, the type of Vertebrata teaches us that partial and total segmentation of the yolk are not inconsistent with unity of type, as the eggs of Mammalia and Cyclostomata undergo a total segmentation, while the process of segmentation is more or less limited in the other classes. In Birds, Reptiles, and Selachians, the segmentation is only superficial; in Batrachians, and most Fishes, it is much deeper; and yet no one would venture to separate the Vertebrata into several distinct branches on that account. With reference to Bryozoa, there can be no doubt, that their association with Polypi or with Worms is contrary to their natural affinities. The plan of their structure is in no way radiate; it is, on the contrary, distinctly and essentially bilateral; and as soon as their close affinities with the Brachiopods, alluded to above,[1] are fully understood, no doubt will remain of their true relation to Mollusks. As it is not within the limits of my plan to illustrate here the characters of all the classes of the animal kingdom, I will only state further, that the branch of Mollusks appears to me to contain only three classes, as follows:—

1st Class: Acephala; with four orders, Bryozoa, including the Vorticellæ, Brachiopods, Tunicata, and Lamellibranchiata.

2d Class: Gasteropoda; with three orders, Pteropoda, Heteropoda, and Gasteropoda proper.

3d Class: Cephalopoda; with two orders, Tetrabranchiata and Dibranchiata.

The most objectionable modification introduced in the general classification of the animal kingdom, since the appearance of Cuvier's Règne Animal, seems to me to be the establishment of a distinct branch, now very generally admitted under the name of VERMES, including the Annulata, the Helminths, the Rotifera, and as Leuckardt would have it, the Bryozoa also. It was certainly an improvement upon Cuvier's system, to remove the Helminths from the type of Radiates, but it was at the same time as truly a retrograde step to separate the Annelides from the branch of Articulata. The most minute comparison does not lead to the discovery of a distinct plan of structure, uniting all these animals into one natural primary group. What holds them together and keeps them at a distance[2] from other groups is not a common plan of structure, but a greater simplicity in their

[1] Chap. I., Sect. 18, p. 72.

[2] Chap. II., Sect. 7, p. 171, 172.

organization.[1] In bringing these animals together, naturalists make again the same mistake which Cuvier committed, when he associated the Helminths with the Radiates, only in another way and upon a greater scale.[2] The Bryozoa are as it were depauperated Mollusks, as Aphanes and Alchemilla are depauperated Rosaceæ. Rotifera are in the same sense the lowest Crustacea; while Helminths and Annelides constitute together the lowest class of Articulata. This class is connected by the closest homology with the larval states of Insects; the plan of their structure is identical, and there exists between them only such structural differences as constitute classes.[3] Moreover, the Helminths are linked to the Annelides in the same manner as the apodal larvæ of Insects are to the most highly organized caterpillars. It may truly be said that the class of Worms represents, in perfect animals, the embryonic states of the higher Articulata. The two other classes of this branch are the Crustacea and the Insects, respecting the limits of which, as much has already been said above,[4] as is necessary to state here.

The classification of the branch of Articulata may, therefore, stand thus:—

1st Class: Worms; with three orders, Trematods, (including Cestods, Planariæ, and Leeches,) Nematoids, (including Acanthocephala and Gordiacei,) and Annelides.

2d Class: Crustacea; with four orders, Rotifera, Entomostraca, (including Cirripeds,) Tetradecapods, and Decapods.

3d Class: Insects; with three orders, Myriapods, Arachnids, and Insects proper.

There is not a dissenting voice among anatomists respecting the natural limits of the Vertebrata, as a branch of the animal kingdom. Their character, however, does not so much consist in the structure of their backbone or the presence of a dorsal cord, as in the general plan of that structure, which exhibits a cavity above and a cavity below a solid axis. These two cavities are circumscribed by complicated arches, arising from the axis, which are made up of different systems of organs, the skeleton, the muscles, vessels, and nerves, and include, the upper one the centres of the nervous system, the lower one the different systems of organs by which assimilation and reproduction are carried on.

The number and limits of the classes of this branch are not yet satisfactorily ascertained. At least, naturalists do not all agree about them. For my part, I believe that the Marsupialia cannot be separated from the Placental Mammalia, as a distinct class, since we observe, within the limits of another type of Vertebrata, the Selachians, which cannot be subdivided into classes, similar differences in the mode of development to those which exist between the Marsupials and the other

[1] See above, Chap. I., Sect. 18, p. 74–78.

[2] Compare Chap. II., Sect. 1, p. 142.

[3] Compare Chap. II., Sect. 2, p. 145.

[4] Compare Chap. I., Sect. 18, p. 78–80.

Mammalia. But I hold, at the same time, with other naturalists, that the Batrachia must be separated, as a class, from the true Reptiles, as the characters which distinguish them are of the kind upon which classes are founded. I am also satisfied that the differences which exist between the Selachians, (the Skates, Sharks, and Chimæræ,) are of the same kind as those which distinguish the Amphibians from the Reptiles proper, and justify, therefore, their separation, as a class, from the Fishes proper. I consider also the Cyclostomes as a distinct class, for similar reasons; but I am still doubtful whether the Ganoids should be separated also from the ordinary Fishes. This, however, cannot be decided until their embryological development has been thoroughly investigated, though I have already collected data which favor this view of the case. Should this expectation be realized, the branch of Vertebrata would contain the following classes:—

1st Class: Myzontes; with two orders, Myxinoids and Cyclostomes.

2d Class: Fishes proper; with two orders, Ctenoids and Cycloids.

3d Class: Ganoids; with three orders, Cœlacanths, Acipenseroids, and Sauroids; and doubtful, the Siluroids, Plectognaths, and Lophobranches.

4th Class: Selachians; with three orders, Chimæræ, Galeodes, and Batides.

5th Class: Amphibians; with three orders, Cæciliæ, Ichthyodi, and Anura.

6th Class: Reptiles; with four orders, Serpentes, Saurii, Rhizodontes, and Testudinata.

7th Class: Birds; with four orders, Natatores, Grallæ, Rasores, and Insessores, (including Scansores and Accipitres.)

8th Class: Mammalia; with three orders, Marsupialia, Herbivora, and Carnivora.

I shall avail myself of an early opportunity to investigate more fully how far these groups of Vertebrata exhibit such characters as distinguish classes, and I submit my present impressions upon this subject, rather as suggestions for further researches, than as matured results.

SECTION II.

EARLY ATTEMPTS TO CLASSIFY ANIMALS.

So few American naturalists have paid special attention to the classification of the animal kingdom in general, that I deem it necessary to allude to the different principles which, at different times, have guided zoölogists in their attempts to group animals according to their natural affinities. This will appear the more

acceptable, I hope, since few of our libraries contain even the leading works of our science, and many zealous students are thus prevented from attempting to study what has thus far been done.

Science has begun, in the introduction of names, to designate natural groups of different value with the same vagueness which still prevails in ordinary language in the use of class, order, genus, family, species; taking them either as synonyms or substituting one for the other at random. Linnæus was the first to urge upon naturalists precision in the use of four kinds of groups in natural history, which he calls classes, orders, genera, and species.

Aristotle, and the ancient philosophers generally, distinguished only two kinds of groups among animals, *γένος* and *εἶδος*, (genus and species.) But the term genus had a most unequal meaning, applying at times indiscriminately to any extensive group of species, and designating even what we now call classes as well as any other minor group. In the sense of class, it is taken in the following case: *λέγω δὲ γένος, οἷον ὄρνιθα, καὶ ἰχθῦν,* (Arist. Hist. Anim., Lib. I., Chap. I.,) while *εἶδος* is generally used for species, as the following sentence shows: *καὶ ἔστιν εἴδη πλείω ἰχθύων καὶ ὀρνίθων,* though it has occasionally also a wider meaning. The sixth chapter of the same book, is the most important in the whole work of Aristotle upon this subject, as it shows to how many different kinds of groups the term *γένος* is applied. Here, he distinguishes between *γένη μέγιστα* and *γένη μεγάλα* and *γένος* shortly. *Γένη δὲ μέγιστα τῶν ζώων, εἰς ἃ διαιρεῖται τἄλλα ζῶα, τάδ' ἔστίν· ἓν μὲν ὀρνίθων, ἓν δ' ἰχθύων, ἄλλο δὲ κήτους. Ἄλλο δὲ γένος ἐστὶ τὸ τῶν ὀστρακοδέρμων. . . . . Τῶν δὲ λοιπῶν ζώων οὐκ ἔστι τὰ γένη μεγάλα· οὐ γὰρ περιέχει πολλὰ εἴδη ἓν εἶδος, ... τὰ δ' ἔχει μὲν, ἀλλ' ἀνώνυμα.* This is further insisted upon anew: *τοῦ δὲ γένους τῶν τετραπόδων ζώων καὶ ζωωτόκων εἴδη μὲν εἰσι πολλὰ, ἀνώνυμα δὲ.* Here *εἶδος* has evidently a wider meaning than our term species, and the accurate Scaliger translates it by *genus medium,* in contradistinction to *γένος,* which he renders by *genus summum. Εἶδος,* however, is generally used in the same sense as now, and Aristotle already considers fecundity as a specific character, when he says, of the Hemionos, that it is called so from its likeness to the Ass, and not because it is of the same species, for he adds, they copulate and propagate among themselves: *αἳ καλοῦνται ἡμίονοι δι' ὁμοιότητα, οὐκ οὖσαι ἁπλῶς τὸ αὐτὸ εἶδος· καὶ γὰρ ὀχεύονται καὶ γεννῶνται ἐξ ἀλλήλων.* In another passage it applies, however, to a group exactly identical with our modern genus Equus: *ἐπεί ἐστιν ἓν τι γένος καὶ ἐπὶ τοῖς ἔχουσι χαίτην, λοφούροις καλουμένοις, οἷον ἵππῳ καὶ ὄνῳ καὶ ὀρεῖ καὶ γίννῳ καὶ ἵννῳ καὶ τοῖς ἐν Συρίᾳ καλουμέναις ἡμιόνοις.*

Aristotle cannot be said to have proposed any regular classification. He speaks constantly of more or less extensive groups, under a common appellation, evidently considering them as natural divisions; but he nowhere expresses a conviction that these groups may be arranged methodically so as to exhibit the natural affinities of animals. Yet he frequently introduces his remarks respecting different animals

in such an order and in such connections as clearly to indicate that he knew their relations. When speaking of Fishes, for instance, he never includes the Selachians.

After Aristotle, the systematic classification of animals makes no progress for two thousand years, until Linnæus introduces new distinctions and assigns a more precise meaning to the terms class, (*genus summum,*) order, (*genus intermedium,*) genus, (*genus proximum,*) and species, the two first of which are introduced by him for the first time as distinct groups, under these names, in the system of Zoölogy.

SECTION III.

PERIOD OF LINNÆUS.

When looking over the "Systema Naturæ" of Linnæus, taking as the standard of our appreciation even the twelfth edition, which is the last he edited himself, it is hardly possible, in our day, to realize how great was the influence of that work upon the progress of Zoölogy.[1] And yet it acted like magic upon the age, and stimulated to exertions far surpassing any thing that had been done in preceding centuries. Such a result must be ascribed partly to the circumstance that he was the first man who ever conceived distinctly the idea of expressing in a definite form, what he considered to be a system of nature, and partly also to the great comprehensiveness, simplicity, and clearness of his method. Discarding in his system every thing that could not easily be ascertained, he for the first time divided the animal kingdom into distinct classes, characterized by definite features; he also for the first time introduced orders into the system of Zoölogy besides genera and species, which had been vaguely distinguished before.[2] And though he did not even attempt to define the characteristics of these different kinds of groups, it is plain, from his numerous writings, that he considered them all as subdivisions of a successively more limited value, embracing a larger or smaller number of animals, agreeing in more or less comprehensive attributes. He expresses

[1] To appreciate correctly the successive improvements of the classification of Linnæus, we need only compare the first edition of the "Systema Naturæ," published in 1735, with the second, published in 1740, the sixth published in 1748, the tenth published in 1758, and the twelfth published in 1766, as they are the only editions he revised himself. The third is only a reprint of the first, the fourth and fifth are reprints of the second; the seventh, eighth, and ninth are reprints of the sixth; the eleventh is a reprint of the tenth; and the thirteenth, published after his death, by Gmelin, is a mere compilation, deserving little confidence.

[2] See above, Sect. 2, p. 188. The *γένη μέγιστα* of Aristotle correspond, however, to the classes of Linnæus; the *γένη μεγάλα* to his orders.

his views of these relations between classes, orders, genera, species, and varieties, by comparisons, in the following manner:—[1]

Classis.	*Ordo.*	*Genus.*	*Species.*	*Varietas.*
Genus summum.	Genus intermedium.	Genus proximum.	Species.	Individuum.
Provinciæ.	Territoria.	Parœciæ.	Pagi.	Domicilium.
Legiones.	Cohortes.	Manipuli.	Contubernia.	Miles.

His arrangement of the animal kingdom is presented in the following diagram, compiled from the twelfth edition, published in 1766.

CLASSIFICATION OF LINNÆUS.

Cl. 1. Mammalia. *Ord.* Primates, Bruta, Feræ, Glires, Pecora, Belluæ, Cete.
Cl. 2. Aves. *Ord.* Accipitres, Picæ, Anseres, Grallæ, Gallinæ, Passeres.
Cl. 3. Amphibia. *Ord.* Reptiles, Serpentes, Nantes.
Cl. 4. Pisces. *Ord.* Apodes, Jugulares, Thoracici, Abdominales.
Cl. 5. Insecta. *Ord.* Coleoptera, Hemiptera, Lepidoptera, Neuroptera, Hymenoptera, Diptera, Aptera.
Cl. 6. Vermes. *Ord.* Intestina, Mollusca, Testacea, Lithophyta, Zoophyta.

In the earlier editions, up to the tenth, the class of Mammalia was called Quadrupedia, and did not contain the Cetaceans, which were still included among the Fishes. There seems never to have existed any discrepancy among naturalists respecting the natural limits of the class of Birds, since it was first characterized by Linnæus, in a manner which excluded the Bats and referred them to the class of Mammalia. In the early editions of the "Systema Naturæ," the class of Reptiles embraces the same animals as in the systems of the most recent investigators; but since the tenth edition, it has been encumbered with the addition of the cartilaginous and semicartilaginous Fishes, a retrograde movement suggested by some inaccurate observations of Dr. Garden. The class of Fishes is very well limited in the early editions of the Systema, with the exception of the admission of the Cetaceans, (Plagiuri,) which were correctly referred to the class of Mammalia, in the tenth edition. In the later editions, however, the Cyclostoms, Plagiostoms, Chimæræ, Sturgeons, Lophioids, Discoboli, Gymnodonts, Scleroderms, and Lophobranches are excluded from it and referred to the class of Reptiles. The class of Insects,[2] as limited by Linnæus, embraces not only what are now considered as

[1] See Systema Naturæ, 12th edit., p. 13.

[2] Aristotle divides this group more correctly than Linnæus, as he admits already two classes, (*γένη μέγιστα*) among them, the Malacostraca, (Crustacea,) and the Entoma, (Insects.) Hist. Anim., Chap. VI. He seems also to have understood correctly the natural limits of the classes of Mammalia and Reptiles, for he distinguishes the Viviparous and Oviparous Quadrupeds, and nowhere confounds Fishes with Reptiles. Ibid.

Insects proper, but also the Myriapods, the Arachnids, and the Crustacea; it corresponds more accurately to the division of Arthropoda of modern systematists. The class of Worms, the most heterogeneous of all, includes besides all Radiata or Zoophytes and the Mollusks of modern writers, also the Worms, intestinal and free, the Cirripeds, and one Fish, (Myxine.) It was left for Cuvier[1] to introduce order in this chaos.

Such is, with its excellences and short-comings, the classification which has given the most unexpected and unprecedented impulse to the study of Zoölogy. It is useful to remember how lately even so imperfect a performance could have so great an influence upon the progress of science, in order to understand why it is still possible that so much remains to be done in systematic Zoölogy. Nothing, indeed, can be more instructive to the student of Natural History, than a careful and minute comparison of the different editions of the "Systema Naturæ" of Linnæus, and of the works of Cuvier and other prominent zoölogists, in order to detect the methods by which real progress is made in our science.

Since the publication of the "Systema Naturæ" up to the time when Cuvier published the results of his anatomical investigations, all the attempts at new classifications were, after all, only modifications of the principles introduced by Linnæus in the systematic arrangement of animals. Even his opponents labored under the influence of his master spirit, and a critical comparison of the various systems which were proposed for the arrangement of single classes or of the whole animal kingdom shows that they were framed according to the same principles, namely, under the impression that animals were to be arranged together into classes, orders, genera, and species, according to their more or less close external resemblance. No sooner, however, had Cuvier presented to the scientific world his extensive researches into the internal structure of the whole animal kingdom, than naturalists vied with one another in their attempts to remodel the whole classification of animals, establishing new classes, new orders, new genera, describing new species, and introducing all manner of intermediate divisions and subdivisions under the name of families, tribes, sections, etc. Foremost in these attempts was Cuvier himself, and next to him Lamarck. It has, however, often happened that the divisions introduced by the latter under new names, were only translations into a more systematic form of the results Cuvier had himself obtained from his dissections and pointed out in his "Leçons sur l'anatomie comparée," as natural divisions, but without giving them distinct names. Cuvier himself beautifully expresses the

[1] It would be injustice to Aristotle not to mention that he understood already the relations of the animals united in one class by Linnæus, under the name of Worms, better than the great Swedish naturalist. Speaking, for instance, of the great genera or classes, he separates correctly the Cephalopods from the other Mollusks, under the name of Malakia. Hist. Anim., Lib. I., Chap. VI.

influence which his anatomical investigations had upon Zoölogy, and how the improvements in classification have contributed to advance comparative anatomy, when he says, in the preface to the "Règne Animal," page vi.: "Je dus donc, et cette obligation me prit un temps considérable, je dus faire marcher de front l'anatomie et la zoologie, les dissections et le classement; chercher dans mes premières remarques sur l'organisation, des distributions meilleures; m'en servir pour arriver à des remarques nouvelles; employer encore ces remarques à perfectionner les distributions; faire sortir enfin de cette fécondation mutuelle des deux sciences l'une par l'autre, un système zoologique propre à servir d'introducteur et de guide dans le champ de l'anatomie, et un corps de doctrine anatomique propre à servir de développement et d'explication au système zoologique."

Without entering into a detailed account of all that was done in this period towards improving the system of Zoölogy, it may suffice to say, that before the first decade of this century had passed, more than twice as many classes as Linnæus adopted had been characterized in this manner. These classes are: the Mollusks, Cirripeds, Crustacea, Arachnids, Annelids, Entozoa, (Intestinal Worms,) Zoophytes, Radiata, Polyps, and Infusoria. Cuvier[1] admitted at first only eight classes, Duméril[2] nine, Lamarck[3] eleven and afterwards fourteen. The Cephalopoda, Gasteropoda, and Acephala, first so named by Cuvier, are in the beginning considered by him as orders only in the class of Mollusks; the Echinoderms also, though for the first time circumscribed by him within their natural limits, constitute only an order of the class of Zoophytes, not to speak of the lowest animals, which, from want of knowledge of their internal structure, still remain in great confusion. In this rapid sketch of the farther subdivisions which the classes Insecta and Worms of Linnæus have undergone under the influence of Cuvier, I have not, of course, alluded to the important contributions made to our knowledge of isolated classes, by special writers, but limited my remarks to the works of those naturalists who have considered the subject upon the most extensive scale.

Thus far, no attempt had been made to combine the classes among themselves into more comprehensive divisions, under a higher point of view, beyond that of dividing the whole animal kingdom into Vertebrata and Invertebrata, a division which corresponds to that of Aristotle, into *ζῶα ἔναιμα* and *ζῶα ἄναιμα*. All efforts were rather directed towards establishing a natural series, from the lowest Infusoria up to Man; which, with many, soon became a favorite tendency, and ended by being presented as a scientific doctrine by Blainville.

[1] CUVIER, (G.,) Tableau élémentaire de l'Histoire naturelle des Animaux, Paris, 1798, 1 vol. 8vo.

[2] DUMÉRIL, (A. M. C.,) Zoologie analytique, etc., Paris, 1806, 1 vol. 8vo.

[3] LAMARCK, (J. B. DE,) Système des Animaux sans Vertèbres ou Tableau général, etc., Paris, 1801, 1 vol. 8vo. — Histoire naturelle des Animaux sans Vertèbres, etc., Paris, 1815–1822, 7 vols. 8vo.

SECTION IV.

PERIOD OF CUVIER, AND ANATOMICAL SYSTEMS.

The most important period in the history of Zoölogy begins, however, with the year 1812, when Cuvier laid before the Academy of Sciences in Paris the results of his investigations upon the more intimate relations of certain classes of the animal kingdom to one another,[1] which had satisfied him that all animals are constructed upon four different plans, or, as it were, cast in four different moulds. A more suggestive view of the subject never was presented before to the appreciation of investigators; and, though it has by no means as yet produced all the results which certainly are to flow from its further consideration, it has already led to the most unquestionable improvements which classification in general has made since the days of Aristotle, and, if I am not greatly mistaken, it is only in as far as that fundamental principle has been adhered to that the changes proposed in our systems, by later writers, have proved a real progress, and not as many retrograde steps.

This great principle, introduced into our science by Cuvier, is expressed by him in these memorable words: "Si l'on considère le règne animal d'après les principes que nous venons de poser, en se débarrassant des préjugés établis sur les divisions anciennement admises, en n'ayant égard qu'à l'organisation et à la nature des animaux, et non pas à leur grandeur, à leur utilité, au plus ou moins de connaissance que nous en avons, ni à toutes les autres circonstances accessoires, on trouvera qu'il existe quatre formes principales, quatre plans généraux, si l'on peut s'exprimer ainsi, d'après lesquels tous les animaux semblent avoir été modelés et dont les divisions ultérieures, de quelque titre que les naturalistes les aient décorées, ne sont que des modifications assez légères fondées sur le développement ou l'addition de quelques parties, qui ne changent rien à l'essence du plan."

It is therefore incredible to me how, in presence of such explicit expressions, Cuvier can be represented, as he is still occasionally, as favoring a division of the animal kingdom into Vertebrata and Invertebrata.[2] Cuvier, moreover, was the first to recognize practically the inequality of all the divisions he adopts in his system; and this constitutes further a great and important step, even though he may not have found the correct measure for all his groups. For we must remember that at the time he wrote, naturalists were bent upon establishing one con-

[1] Ann. du Muséum d'Histoire Naturelle, vol. xix., Paris, 1812.

[2] EHRENBERG, (C. G.,) Die Corallenthiere des rothen Meeres, Berlin, 1834, 4to., p. 30, note.

tinual uniform series to embrace all animals, between the links of which it was supposed there were no unequal intervals. The watchword of their school was: *Natura non facit saltum.* They called their system *la chaine des êtres.*

The views of Cuvier led him to the following arrangement of the animal kingdom: —

CLASSIFICATION OF CUVIER.[1]

First Branch. ANIMALIA VERTEBRATA.

CL. 1. Mammalia. *Orders*: Bimana, Quadrumana, Carnivora, Marsupialia, Rodentia, Edentata, Pachydermata, Ruminantia, Cetacea.

CL. 2. Birds. *Ord.* Accipitres, Passeres, Scansores, Gallinæ, Grallæ, Palmipedes.

CL. 3. Reptilia. *Ord.* Chelonia, Sauria, Ophidia, Batrachia.

CL. 4. Fishes. 1*st Series*: Fishes proper. *Ord.* Acanthopterygii; — Abdominales, Subbrachii, Apodes; — Lophobranchii, Plectognathi; 2*d Series*: Chondropterygii. *Ord.* Sturiones, Selachii, Cyclostomi.[2]

Second Branch. ANIMALIA MOLLUSCA.

CL. 1. Cephalopoda. No subdivisions into orders or families.

CL. 2. Pteropoda. No subdivisions into orders or families.

CL. 3. Gasteropoda. *Ord.* Pulmonata, Nudibranchia, Inferobranchia, Tectibranchia, Heteropoda, Pectinibranchia, Tubulibranchia, Scutibranchia, Cyclobranchia.

CL. 4. Acephala. *Ord.* Testacea, Tunicata.

CL. 5. Brachiopoda. No subdivisions into orders or families.

CL. 6. Cirrhopoda. No subdivisions into orders or families.

Third Branch. ANIMALIA ARTICULATA.

CL. 1. Annelides. *Ord.* Tubicolæ, Dorsibranchiæ, Abranchiæ.

CL. 2. Crustacea. 1*st Section*: Malacostraca. *Ord.* Decapoda, Stomapoda, Amphipoda, Læmodipoda, Isopoda. 2*d Section*: Entomostraca. *Ord.* Branchiopoda, Poecilopoda, Trilobitæ.

CL. 3. Arachnides. *Ord.* Pulmonariæ, Trachearіæ.

CL. 4. Insects. *Ord.* Myriapoda, Thysanura, Parasita, Suctoria, Coleoptera, Orthoptera, Hemiptera, Neuroptera, Hymenoptera, Lepidoptera, Rhipiptera, Diptera.

Fourth Branch. ANIMALIA RADIATA.

CL. 1. Echinoderms. *Ord.* Pedicellata, Apoda.

CL. 2. Intestinal Worms. *Ord.* Nematoidea, (incl. Epizoa and Entozoa,) Parenchymatosa.

CL. 3. Acalephae. *Ord.* Simplices, Hydrostaticæ.

CL. 4. Polypi. (Including Anthozoa, Hydroids, Bryozoa, Corallinæ, and Spongiæ.) *Ord.* Carnosi, Gelatinosi, Polypiarii.

CL. 5. Infusoria. *Ord.* Rotifera and Homogenea, (including Polygastrica and some Algæ.)

[1] Le Règne animal distribué d'après son organisation, Paris, 1829, 2de édit. 5 vols. 8vo. The classes of Crustacea, Arachnids, and Insects have been elaborated by Latreille. For the successive modifications the classification of Cuvier has undergone, compare his Tableau élémentaire, q. a., p. 192, his paper, q. a., p. 193, and the first edition of the Règne animal, published in 1817, in 4 vols. 8vo.

[2] Comp. Règn. Anim., 2de édit., 2d vol., p. 128 and 383.

When we consider the zoölogical systems of the past century, that of Linnæus, for instance, and compare them with more recent ones, that of Cuvier, for example, we cannot overlook the fact, that even when discoveries have added little to our knowledge, the subject is treated in a different manner; not merely in consequence of the more extensive information respecting the internal structure of animals, but also respecting the gradation of the higher groups.

Linnæus had no divisions of a higher order than classes. Cuvier introduced, for the first time, four great divisions, which he called "*embranchemens*" or branches, under which he arranged his classes, of which he admitted three times as many as Linnæus had done.

Again, Linnæus divides his classes into orders; next, he introduces genera, and finally, species; and this he does systematically in the same gradation through all classes, so that each of his six classes is subdivided into orders, and these into genera with their species. Of families, as now understood, Linnæus knows nothing.

The classification of Cuvier presents no such regularity in its framework. In some classes he proceeds, immediately after presenting their characteristics, to the enumeration of the genera they contain, without grouping them either into orders or families. In other classes, he admits orders under the head of the class, and then proceeds to the characteristics of the genera, while in others still, he admits under the class not only orders and families, placing always the family in a subordinate position to the order, but also a number of secondary divisions which he calls sections, divisions, tribes, etc., before he reaches the genera and species. With reference to the genera again, we find marked discrepancies in different classes. Sometimes a genus is to him an extensive group of species, widely differing one from the other, and of such genera he speaks as "grands genres;" others are limited in their extent, and contain homogeneous species without farther subdivisions, while still others are subdivided into what he calls sub-genera, and this is usually the case with his "great genera."

The gradation of divisions with Cuvier varies then with his classes, some classes containing only genera and species, and neither orders nor families nor any other subdivision. Others contain orders, families, and genera, and besides these, a variety of subdivisions of the most diversified extent and significance. This remarkable inequality between all the divisions of Cuvier is, no doubt, partly owing to the state of Zoölogy and of zoölogical museums at the time he wrote, and to his determination to admit into his work only such representatives of the animal kingdom as he could to a greater or less extent examine anatomically for himself; but it is also partly to be ascribed to his conviction, often expressed, that there is no such uniformity or regular serial gradation among animals as many naturalists attempted to introduce into their classifications.

CLASSIFICATION OF LAMARCK.

Histoire naturelle des Animaux sans vertèbres, etc., Paris, 1815–1822, 7 vols. 8vo. — A second edition with notes has been published by Messrs. DesHayes and Milne-Edwards, Paris, 1835–1843, 10 vols. 8vo. — For the successive modifications this classification has undergone, see also: Système des animaux sans vertèbres, etc., Paris, 1801, 8vo. — Philosophie zoologique, etc., Paris, 1809, 2 vols. 8vo. — Extrait du Cours de Zoologie du Muséum d'Histoire naturelle, etc., Paris, 1812, 8vo.

INVERTEBRATA.

I. APATHETIC ANIMALS.

- CL. 1. Infusoria. *Ord.* Nuda, Appendiculata.
- CL. 2. Polypi. *Ord.* Ciliati (Rotifera), Denudati (Hydroids), Vaginati (Anthozoa and Bryozoa), and Natantes (Crinoids, and some Halcyonoids.)
- CL. 3. Radiaria. *Ord.* Mollia (Acalephæ), Echinoderms, (including Holothuriæ and Actiniæ.)
- CL. 4. Tunicata. *Ord.* Bothryllaria (Compound Ascidians), Ascidia, (Simple Ascidians.)
- CL. 5. Vermes. *Ord.* Molles and Rigiduli (Intestinal Worms and Gordius), Hispiduli (Nais), Epizoariæ (Epizoa, Lernæans.)

Do not feel, and move only by their excited irritability. No brain, nor elongated medullary mass; no senses; forms varied; rarely articulations.

II. SENSITIVE ANIMALS.

- CL. 6. Insects. (Hexapods.) *Ord.* Aptera, Diptera, Hemiptera, Lepidoptera, Hymenoptera, Nevroptera, Orthoptera, Coleoptera.
- CL. 7. Arachnids. *Ord.* Antennato-tracheales (Thysanura and Myriapoda), Exantennato-tracheales and Exantennato-branchiales (Arachnids proper.)
- CL. 8. Crustacea. *Ord.* Heterobranchia (Branchipoda, Isopoda, Amphipoda, Stomapoda) and Homobranchia (Decapoda.)
- CL. 9. Annelids. *Ord.* Apoda, Antennata, Sedentaria.
- CL. 10. Cirripeds. *Ord.* Sessilia and Pedunculata.
- CL. 11. Conchifera. *Ord.* Dimyaria, Monomyaria.
- CL. 12. Mollusks. *Ord.* Pteropoda, Gasteropoda, Trachelipoda, Cephalopoda, Heteropoda.

Feel, but obtain from their sensations only perceptions of objects, a sort of simple ideas, which they are unable to combine to obtain complex ones. No vertebral column; a brain and mostly an elongated medullary mass; some distinct senses; muscles attached under the skin; form symmetrical, the parts being in pairs.

VERTEBRATA.

III. INTELLIGENT ANIMALS.

- CL. 13. Fishes.
- CL. 14. Reptiles.
- CL. 15. Birds.
- CL. 16. Mammalia.

Feel; acquire preservable ideas; perform with them operations by which they obtain others; are intelligent in different degrees. A vertebral column; a brain and a spinal marrow; distinct senses; the muscles attached to the internal skeleton; form symmetrical, the parts being in pairs.

It is not easy to appreciate correctly the system of Lamarck, as it combines abstract conceptions with structural considerations, and an artificial endeavor to arrange all animals in continuous series. The primary subdivision of the animal kingdom into Invertebrata and Vertebrata[1] corresponds, as I have stated above, to

[1] See, above, Chap. 2, Sect. 1, p. 138.

that of *Anaima* and *Enaima* of Aristotle. The three leading groups designated under the name of Apathetic, Sensitive, and Intelligent animals, are an imitation of the four branches of Cuvier; but, far from resting upon such a definite idea as the divisions of Cuvier, which involve a special plan of structure, they are founded upon the assumption that the psychical faculties of animals present a serial gradation, which, when applied as a principle of classification, is certainly not admissible. To say that neither Infusoria, nor Polypi, nor Radiata, nor Tunicata, nor Worms feel, is certainly a very erroneous assertion. They manifest sensations quite as distinctly as many of the animals included in the second type which are called Sensitive. And as to the other assertion, that they move only by their excited irritability, we need only watch the Starfishes to be satisfied that their motions are determined by internal impulses and not by external excitation. Modern investigations have shown that most of them have a nervous system, and many even organs of senses.

The Sensitive animals are distinguished from the third type, the Intelligent animals, by the character of their sensations. It is stated, in respect to the Sensitive animals, that they obtain from their sensations only perceptions of objects, a sort of simple ideas which they are unable to combine so as to derive from them complex ones, while the Intelligent animals are said to obtain ideas which they may preserve, and to perform with them operations by which they arrive at new ideas. They are said to be Intelligent. Even now, fifty years after Lamarck made those assertions, I doubt whether it is possible to distinguish in that way between the sensations of the Fishes, for instance, and those of the Cephalopods. It is true, the structure of the animals called Sensitive and Intelligent by Lamarck differs greatly, but a large number of his Sensitive animals are constructed upon the same plan as many of those he includes among the Apathetic; they embrace, moreover, two different plans of structure, and animal psychology is certainly not so far advanced as to afford the least foundation for the distinctions here introduced.

Even from his own point of view, his arrangement of the classes is less perfect than he might have made it, as the Annelids stand nearer to the Worms than the Insects, and are very inferior to them. Having failed to perceive the value of the idea of plan, and having substituted for it that of a more or less complicated structure, Lamarck unites among his Apathetic animals, Radiates (the Polypi and Radiaria) with Mollusks, (the Tunicata,) and with Articulates (the Worms.) Among the Sensitive animals, he unites Articulates (the Insects, Arachnids, Crustacea, Annelids, and Cirripeds) with Mollusks (the Conchifera, and the Mollusks proper.) Among the Intelligent animals, he includes the ancient four classes of Vertebrates, the Fishes, Reptiles, Birds, and Mammalia.

CLASSIFICATION OF DE BLAINVILLE.[1]

1. *Sub-Kingdom.* *Artiomorpha or Artiozoaria.* Form bilateral.
   - First Type: OSTEOZOARIA. (Vertebrata.)
     - Sub-Type: *Vivipara.*
       - CL. 1. Pilifera, or Mammifera. 1st. Monadelphya. 2d. Didelphya.
     - Sub-Type: *Ovipara.*
       - CL. 2. Pennifera, or Aves.
       - CL. 3. Squamifera, or Reptilia.
       - CL. 4. Nudipellifera, or Amphibia.
       - CL. 5. Pinnifera, or Pisces.

     Anosteozoaria.
   - Second Type: ENTOMOZOARIA. (Articulata.)
     - CL. 6. Hexapoda. (Insecta proprie sic dicta.)
     - CL. 7. Octopoda. (Arachnida.)
     - CL. 8. Decapoda. (Crustacea, Decapoda, and Limulus.)
     - CL. 9. Heteropoda. (Squilla, Entomostraca, and Epizoa.)
     - CL. 10. Tetradecapoda. (Amphipoda and Isopoda.)
     - CL. 11. Myriapoda.
     - CL. 12. Chætopoda. (Annelides.)
     - CL. 13. Apoda. (Hirudo, Cestoidea, Ascaris.)
   - Third Type: MALENTOZOARIA.
     - CL. 14. Nematopoda. (Cirripedia.)
     - CL. 15. Polyplaxiphora. (Chiton.)
   - Fourth Type: MALACOZOARIA. (Mollusca.)
     - CL. 16. Cephalophora. Dioïca, (Cephalopoda and Gasteropoda, p. p.) Hermaphrodita and Monoïca (Gasteropoda reliqua.)
     - CL. 17. Acephalophora. Palliobranchia (Brachiopoda), Lamellibranchia (Acephala), Heterobranchia (Ascidiæ.)
2. *Sub-Kingdom.* *Actinomorpha* or *Actinozoaria.* Form radiate.
   - CL. 18. Annelidaria, or Gastrophysaria (Sipunculus, etc.)
   - CL. 19. Ceratodermaria. (Echinodermata.)
   - CL. 20. Arachnodermaria. (Acalephæ.)
   - CL. 21. Zoantharia. (Actiniæ.)
   - CL. 22. Polypiaria. (Polypi tentaculis simplicibus), (Anthozoa and Bryozoa.)
   - CL. 23. Zoophytaria. (Polypi tentaculis compositis), (Halcyonoidea.)
3. *Sub-Kingdom.* *Heteromorpha* or *Heterozoaria.* Form irregular.
   - CL. 24. Spongiaria. (Spongiæ.)
   - CL. 25. Monadaria. (Infusoria.)
   - CL. 26. Dendrolitharia. (Corallinæ.)

The classification of de Blainville resembles those of Lamarck and Cuvier much more than a diagram of the three would lead us to suppose. The first of these systems is founded upon the idea that the animal kingdom forms one gradated

[1] De l'Organisation des Animaux, Paris, 1822, 1 vol. 8vo.

series; only that de Blainville inverts the order of Lamarck, beginning with the highest animals and ending with the lowest. With that idea is blended, to some extent, the view of Cuvier, that animals are framed upon different plans of structure; but so imperfectly has this view taken hold of de Blainville, that instead of recognizing at the outset these great plans, he allows the external form to be the leading idea upon which his primary divisions are founded, and thus he divides the animal kingdom into three sub-kingdoms: the first, including his Artiozoaria, with a bilateral form; the second, his Actinozoaria, with a radiated form, and the third, his Heterozoaria, with an irregular form (the Sponges, Infusoria, and Corallines.) The plan of structure is only introduced as a secondary consideration, upon which he establishes four types among the Artiozoaria: 1st. The Osteozoaria, corresponding to Cuvier's Vertebrata; 2d. The Entomozoaria, corresponding to Cuvier's Articulata; 3d. The Malentozoaria, which are a very artificial group, suggested only by the necessity of establishing a transition between the Articulata and Mollusca; 4th. The Malacozoaria, corresponding to Cuvier's Mollusca. The second sub-kingdom, Actinozoaria, corresponds to Cuvier's Radiata, while the third sub-kingdom, Heterozoaria, contains organized beings which for the most part do not belong to the animal kingdom. Such at least are his Spongiaria and Dendrolitharia, whilst his Monodaria answer to the old class of Infusoria, about which enough has already been said above. It is evident, that what is correct in this general arrangement is borrowed from Cuvier; but it is only justice to de Blainville to say, that in the limitation and arrangement of the classes, he has introduced some valuable improvements. Among Vertebrata, for instance, he has, for the first time, distinguished the class of Amphibia from the true Reptiles. He was also the first to remove the Intestinal Worms from among the Radiata to the Articulata; but the establishment of a distinct type for the Cirripedia and Chitons was a very mistaken conception. Notwithstanding some structural peculiarities, the Chitons are built essentially upon the same plan as the Mollusks of the class Gasteropoda, and the investigations, made not long after the publication of de Blainville's system, have left no doubt that Cirripedia are genuine Crustacea. The supposed transition between Articulata and Mollusks, which de Blainville attempted to establish with his type of Malentozoaria, certainly does not exist in nature.

If we apply to the classes of de Blainville the test introduced in the preceding chapter, it will be obvious that his Decapoda, Heteropoda, and Tetradecapoda partake more of the character of orders than of that of classes, whilst among Mollusks, his class Cephalophora certainly includes two classes, as he has himself acknowledged in his later works. Among Radiata his classes Zoantharia, Polypiaria, and Zoophytaria partake again of the character of orders and not of those of classes. One great objection to the system of de Blainville is, the useless introduction of so

many new names for groups which had already been correctly limited and well named by his predecessors. He had, no doubt, a desirable object in view in doing this,—he wished to remove some incorrect names; but he extended his reform too far when he undertook to change those also which did not suit his system.

CLASSIFICATION OF EHRENBERG.

The characteristics of the following twenty-eight classes of animals, with a twenty-ninth for Man alone, are given more fully in the Transactions of the Academy of Berlin for 1836, in the paper q. a., p. 138.

1st Cycle: NATIONS. Mankind, constituting one distinct class, is characterized by the equable development of all systems of organs, in contradistinction of the

2d Cycle: ANIMALS, which are considered as characterized by the prominence of single systems. These are divided into:

A. Myeloneura.

I. NUTRIENTIA. Warm-blooded Vertebrata, taking care of their young.
- CL. 1. Mammalia.
- CL. 2. Birds.

II. ORPHANOZOA. Cold-blooded Vertebrata, taking no care of their young.
- Cl. 3. Amphibia.
- Cl. 4. Pisces.

B. Ganglioneura.

A. Sphygmozoa, Cordata.

Circulation marked by a heart or pulsating vessels.

III. ARTICULATA. Real articulation, marked by rows of ganglia and their ramifications.
- CL. 5. Insecta.
- CL. 6. Arachnoidea.
- CL. 7. Crustacea (including Entomostraca, Cirripedia, and Lernæa.)
- CL. 8. Annulata. (The genuine Annelids exclusive of Nais.)
- CL. 9. Somatotoma. (Naidina.)

IV. MOLLUSCA. No articulation. Ganglia dispersed.
- CL. 10. Cephalopoda.
- CL. 11. Pteropoda.
- CL. 12. Gasteropoda.
- CL. 13. Acephala.
- CL. 14. Brachiopoda.
- CL. 15. Tunicata. (Ascidiæ simplices.)
- CL. 16. Aggregata. (Ascidiæ compositæ.)

B. Asphycta, Vasculosa.

Vessels without pulsation.

V. TUBULATA. No real articulation. Intestine, a simple sac or tube.
- CL. 17. Bryozoa.
- CL. 18. Dimorphæa. (Hydroids.)
- CL. 19. Turbellaria. (Rhabdocœla: Derostoma, Turbella, Vortex.)
- CL. 20. Nematoidea. (Entozoa, with simple intestine; also Gordius and Anguillula.)
- CL. 21. Rotatoria.
- CL. 22. Echinoidea. (Echinus, Holothuria, Sipunculus.)

VI. RACEMIFERA. Intestine divided, or forked, radiating, dendritic, or racemose.
- CL. 23. Asteroidea.
- CL. 24. Acalephae.
- CL. 25. Anthozoa.
- CL. 26. Trematodea. (Entozoa with ramified intestine, also Cercaria.)
- CL. 27. Complanata. (Dendrocœla: Planaria, etc.)
- CL. 28. Polygastrica.

The system of Zoölogy, published by Ehrenberg in 1836, presents many new views in almost all its peculiarities. The most striking of its features is the principle laid down, that the type of development of animals is one and the same from Man to the Monad, implying a complete negation of the principle advocated by Cuvier, that the four primary divisions of the animal kingdom are characterized by different plans of structure. It is very natural that Ehrenberg, after having illustrated so fully and so beautifully as he did, the natural history of so many organized beings, which up to the publication of his investigations were generally considered as entirely homogeneous, after having shown how highly organized and complicated the internal structure of many of them is, after having proved the fallacy of the prevailing opinions respecting their origin, should have been led to the conviction that there is, after all, no essential difference between these animals, which were then regarded as the lowest, and those which were placed at the head of the animal creation. The investigator, who had just revealed to the astonished scientific world the complicated systems of organs which can be traced in the body of microscopically small Rotifera, must have been led irresistibly to the conclusion that all animals are equally perfect, and have assumed, as a natural consequence of the evidence he had obtained, that they stand on the same level with one another, as far as the complication of their structure is concerned. Yet the diagram of his own system shows, that he himself could not resist the internal evidence of their unequal structural endowment. Like all other naturalists, he places Mankind at one end of the animal kingdom, and such types as have always been considered as low, at the other end.

Man constitutes, in his opinion, an independent cycle, that of nations, in contradistinction to the cycle of animals, which he divides into MYELONEURA, those with nervous marrow (the Vertebrata,) and GANGLIONEURA, those with ganglia (the Invertebrata.) The Vertebrata he subdivides into *Nutrientia*, those which take care of their young, and *Orphanozoa*, those which take no care of their young, though this is not strictly true, as there are many Fishes and Reptiles which provide as carefully for their young as some of the Birds and Mammalia, though they do it in another way. The Invertebrata are subdivided into *Sphygmozoa*, those which have a heart or pulsating vessels, and *Asphycta*, those in which the vessels do not pulsate. These two sections are further subdivided: the first, into Articulata with real articulations and rows of ganglia, and Mollusks without articulation and with dispersed ganglia; the second, into Tubulata with a simple intestine, and Racemifera with a branching intestine. These characters, which Ehrenberg assigns to his leading divisions, imply necessarily the admission of a gradation among animals. He thus negatives, in the form in which he expresses the results of his investigations, the very principle he intends to illustrate by his diagram. The peculiar view of Ehrenberg, that

all animals are equal in the perfection of their organization, might be justified, if it was qualified so as to imply a relative perfection, adapted in all to the end of their special mode of existence. As no one observer has contributed more extensively than Ehrenberg to make known the complicated structure of a host of living beings, which before him were almost universally believed to consist of a simple mass of homogeneous jelly, such a view would naturally be expected of him. But this qualified perfection is not what he means. He does not wish to convey the idea that all animals are equally perfect in their way, for he states distinctly that "Infusoria have the same sum of systems of organs as Man," and the whole of his system is intended to impress emphatically this view. The separation of Man from the animals, not merely as a class but as a still higher division, is especially maintained upon that ground.

The principle of classification adopted by Ehrenberg is purely anatomical; the idea of type is entirely set aside, as is shown by the respective position of his classes. The Myeloneura, it is true, correspond to the branch of Vertebrata, and the Sphygmozoa to the Articulata and Mollusca; but they are not brought together on the ground of the typical plan of their structure, but because the first have a spinal marrow and the other a heart or pulsating vessels with or without articulations of the body. In the division of Tubulata, it is still more evident how the plan of their structure is disregarded, as that section embraces Radiata, (the Echinoidea and the Dimorphæa,) Mollusca, (the Bryozoa,) and Articulata, (the Turbellaria, the Nematoidea, and the Rotatoria,) which are thus combined simply on the ground that they have vessels which do not pulsate, and that their intestine is a simple sac or tube. The Racemifera contain also animals constructed upon different plans, united on account of the peculiar structure of the intestine, which is either forked or radiating, dendritic or racemose.

The limitation of many of the classes proposed by Ehrenberg is quite objectionable, when tested by the principles discussed above. A large proportion of them are, indeed, founded upon ordinal characters only, and not upon class characters. This is particularly evident with the Rotatoria, the Somatotoma, the Turbellaria, the Nematoidea, the Trematodea, and the Complanata, all of which belong to the branch of Articulata. The Tunicata, the Aggregata, the Brachiopoda, and the Bryozoa are also only orders of the class Acephala. Before Echinoderms had been so extensively studied as of late, the separation of the Echinoidea from Asteroidea might have seemed justifiable; at the present day, it is totally inadmissible. Even Leuckart, who considers the Echinoderms as a distinct branch of the animal kingdom, insists upon the necessity of uniting them as a natural group. As to the Dimorphæa, they constitute a natural order of the class Acalephæ, which is generally known by the name of Hydroids.

CLASSIFICATION OF BURMEISTER.

The following diagram is compiled from the author's Geschichte der Schöpfung, Leipzig, 1843, 1 vol. 8vo.

Type I. IRREGULAR ANIMALS.
- 1st Subtype. CL. 1. Infusoria.

Type II. REGULAR ANIMALS.
- 2d Subtype. CL. 2. Polypina. *Ord.* Bryozoa, Anthozoa.
- 3d Subtype. CL. 3. Radiata. *Ord.* Acalephæ, Echinodermata, Scytodermata.

Type III. SYMMETRICAL ANIMALS.
- 4th Subtype. CL. 4. Mollusca. *Ord.* Perigymna (Tunicata); Cormopoda (Acephala); Brachiopoda, Cephalophora (Pteropoda and Gasteropoda); Cephalopoda.
- 5th Subtype. Arthrozoa.
  - CL. 5. Vermes. *Ord.* Helminthes, Trematodes, and Annulati.
  - CL. 6. Crustacea. 1°. Ostracoderma. *Ord.* Prothesmia (Cirripedia, Siphonostoma, and Rotatoria); Aspidostraca (Entomostraca: Lophyropoda, Phyllopoda, Pæcilopoda, Trilobitæ.) 2°. Malacostraca. *Ord.* Thoracostraca (Podophthalma); and Arthrostraca, (Edriophthalma.)
  - CL. 7. Arachnoda. *Ord.* Myriapoda, Arachnidæ.
  - CL. 8. Insecta. *Ord.* Rhynchota, Synistata, Antliata, Piezata, Glossata, Eleutherata.
- 6th Subtype. Osteozoa. (Vertebrata.)
  - CL. 9. Pisces.
  - CL. 10. Amphibia.
  - CL. 11. Aves.
  - CL. 12. Mammalia.

The general arrangement of the classification of Burmeister recalls that of de Blainville; only that the order is inverted. His three types correspond to the three subkingdoms of de Blainville: the Irregular Animals to the Heterozoaria, the Regular Animals to the Actinozoaria, and the Symmetrical Animals to the Artiozoaria; while his subtypes of the Symmetrical Animals correspond to the types de Blainville admits among his Artiozoaria, with this important improvement, however, that the Malentozoaria are suppressed. Burmeister reduces, unhappily, the whole branch of Mollusks to one single class. The Arthrozoa, on the contrary, in the investigation of which Burmeister has rendered eminent service to science, are presented in their true light. In his special works,[1] his classification of the Articulata is presented with more details. I have no doubt that the correct views he entertains respecting the standing of the Worms in the branch of Articulata are owing to his extensive acquaintance with the Crustacea and Insects, and their metamorphoses.

[1] These works are: Beiträge zur Naturgeschichte der Rankenfüsser, (Cirripedia,) Berlin, 1834, 1 vol. 4to. — Handbuch der Entomologie, Berlin, 1832–47, 5 vols. 8vo.; Engl. by W. E. Shuckard, London, 1836. — Die Organisation der Trilobiten, aus ihren lebenden Verwandten entwickelt, Berlin, 1843, 1 vol. 4to.; Engl. by the Ray Society, London, 1847, 1 vol. fol.

CLASSIFICATION OF OWEN.

The following diagram is compiled from R. OWEN's Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals, 2d edit., London, 1855, 1 vol. 8vo.

Province. VERTEBRATA. Myelencephala. (Owen.)

CL. Mammalia.
CL. Aves.
CL. Reptilia.

} The classes Mammalia, Aves, and Reptilia are not yet included in the second volume of the "Lectures," the only one relating to Vertebrata thus far published.

CL. Pisces. *Ord.* Dermopteri, Malacopteri, Pharyngognathi, Anacanthini, Acanthopteri, Plectognathi, Lophobranchii, Ganoidei, Protopteri, Holocephali, Plagiostomi.

Province. ARTICULATA. Homogangliata. (Owen.)

CL. Arachnida. *Ord.* Dermophysa, Trachearia, Pulmotrachearia, and Pulmonaria.

CL. Insecta. *Subclass:* Myriapoda. *Ord.* Chilognatha and Chilopoda. *Subclass:* Hexapoda. *Ord.* Aptera, Diptera, Lepidoptera, Hymenoptera, Homoptera, Strepsiptera, Nevroptera, Orthoptera, and Coleoptera.

CL. Crustacea. *Subclass:* Entomostraca. *Ord.* Trilobites, Xiphosura, Phyllopoda, Cladocera, Ostracopoda, Copepoda. *Subclass:* Malacostraca. 1°. Edriophthalma. *Ord.* Læmodipoda, Isopoda, Amphipoda. 2°. Podophthalma. *Ord.* Stomapoda, Decapoda.

CL. Epizoa. *Ord.* Cephaluna, Brachiuna, and Onchuna.

CL. Annellata. *Ord.* Suctoria, Terricola, Errantia, Tubicola.

CL. Cirripedia. *Ord.* Thoracica, Abdominalia, and Apoda.

Province. MOLLUSCA. Heterogangliata. (Owen.)

CL. Cephalopoda. *Ord.* Tetrabranchiata and Dibranchiata.

CL. Gasteropoda. A. Monœcia: *Ord.* Apneusta (Köll.), Nudibranchiata, Inferobranchiata, Tectibranchiata, Pulmonata. B. Diœcia. *Ord.* Nucleobranchiata, Tubulibranchiata, Cyclobranchiata, Scutibranchiata, and Pectinibranchiata.

CL. Pteropoda. *Ord.* Thecosomata and Gymnosomata.

CL. Lamellibranchiata. *Ord.* Monomyaria and Dimyaria.

CL. Brachiopoda. Only subdivided into families.

CL. Tunicata. *Ord.* Saccobranchiata and Tæniobranchiata.

Subprovince. RADIARIA.[1]

CL. Echinodermata. *Ord.* Crinoidea, Asteroidea, Echinoidea, Holothurioidea, and Sipunculoidea.

CL. Bryozoa. Only subdivided into families.

CL. Anthozoa. Only subdivided into families.

CL. Acalephae. *Ord.* Pulmograda, Ciliograda, and Physograda.

CL. Hydrozoa. Only subdivided into families.

Subprovince. ENTOZOA.

CL. Cœlelmintha. *Ord.* Gordiacea, Nematoidea, and Onchophora.

CL. Sterelmintha. *Ord.* Tænioidea, Trematoda, Acanthocephala. — Turbellaria.

Subprovince. INFUSORIA.

CL. Rotifera. Only subdivided into families.

CL. Polygastria. *Ord.* Astoma, Stomatoda. — Rhizopoda.

[1] In the first edition of the work quoted above, published in 1843, the three subprovinces, Radiaria, Entozoa, and Infusoria are considered as one subkingdom called Radiata, in contradistinction of the subkingdoms, Mollusca, Articulata, and Vertebrata, and that subkingdom is subdivided into two groups, *Nematoneura* and *Acrita*.

The classification with which Owen[1] introduces his "Lectures on Comparative Anatomy" is very instructive, as showing, more distinctly than other modern systems, the unfortunate ascendency which the consideration of the complication of structure has gained of late over the idea of plan. His provinces, it is true, correspond in the main to the branches of Cuvier, with this marked difference, however, that he does not recognize a distinct province of Radiata coequal with those of Mollusca, Articulata, and Vertebrata, but only admits Radiaria as a subprovince on a level with Entozoa and Infusoria. Here, the idea of simplicity of structure evidently prevails over that of plan, as the subprovinces Radiaria, Entozoa, and Infusoria embrace, besides true Radiata, the lowest types of two other branches, Mollusks and Articulates. On the other hand, his three subprovinces correspond to the first three types of von Siebold; the Infusoria[2] of Owen embracing the same animals as the Protozoa of Siebold, his Entozoa[3] the same as the Vermes, and his Radiaria the same as the Zoophyta, with the single exception that Owen refers the Annellata to the province of Articulata, whilst Siebold includes them among his Vermes. Beyond this the types of Mollusca and Articulata (Arthropoda) of the two distinguished anatomists entirely agree. The position assigned by Owen to the provinces Articulata and Mollusca, not one above the other, but side by side with one another,[4] is no doubt meant to express his conviction, that the complication of structure of these two types does not justify the idea that either of them stands higher or lower than the other; and this is perfectly correct.

Several groups, established by previous writers as families or orders, are here admitted as classes. His class EPIZOA, which is not to be confounded with that established by Nitzsch under the same name, corresponds exactly to the family called LERNÉES by Cuvier. His class HYDROZOA answers to the order HYDROIDA of Johnston, and is identical with the class called DIMORPHÆA by Ehrenberg. His class CŒLELMINTHA corresponds to the order of INTESTINAUX CAVITAIRES established

[1] I have given precedence to the classification of Owen over those of von Siebold and Stannius, Milne-Edwards, Leuckart, etc., because the first edition of the "Lectures on Comparative Anatomy" was published in 1843; but in estimating its features, as expressed in the preceding diagram, it should be borne in mind that, in the first edition, the classes alone are considered, and that the orders and families were only added to the second edition in 1855. I mention this simply to prevent the possibility of being understood as ascribing to Owen all those subdivisions of the classes, which he admits, and which do not appear in the systems considered before his.

[2] The Rhizopoda are considered as a group coequal to Rotifera and Polygastria, on p. 16 of the "Lectures," but on p. 59, they stand as a suborder of Polygastria.

[3] The Turbellaria are represented as an independent group, on p. 16, and referred as a suborder to the Trematoda, on p. 118.

[4] From want of room, I have been compelled, in reproducing the classification of Owen in the preceding diagram, to place his provinces Articulata and Mollusca one below the other upon my page; according to his views, they should stand on a level, side by side with one another.

by Cuvier, with the addition of Gordius; while his class STERELMINTHA has the same circumscription as the order INTESTINAUX PARENCHYMATEUX of Cuvier. Generally speaking, it should not be understood that the secondary divisions mentioned by the different authors, whose systems I have analyzed here, were established by them. They are frequently borrowed from the results obtained by special investigators of isolated classes. But it would lead me too far, to enter here into a discussion of all these details.

This growing resemblance of the modern systems of Zoölogy is a very favorable sign of our times. It would, indeed, be a great mistake to assume, that it is solely owing to the influence of different authors upon one another; it is, on the contrary, to a very great extent, the result of our better acquaintance with Nature. When investigators, at all conversant with the present state of our science, must possess nearly the same amount of knowledge, it is self-evident that their views can no longer differ so widely as they did when each was familiar only with a part of the subject. A deeper insight into the animal kingdom must, in the end, lead to the conviction that it is not the task of zoölogists to introduce order among animals, but that their highest aim should be simply to read the natural affinities which exist among them, so that the more nearly our knowledge embraces the whole field of investigation, the more closely will our opinions coincide.

As to the value of the classes adopted by Owen, I may further remark that recent investigations, of which he might have availed himself, have shown that the Cirripedia and his Epizoa are genuine Crustacea, and that the Entozoa can no longer be so widely separated from the Annellata as in his system. With reference to the other classes, I refer the reader to my criticism of older systems, and to the first section of this Chapter.

It is a great satisfaction for me to find that the views I have advocated in the preceding sections, respecting the natural relations of the leading groups of the animal kingdom, coincide so closely with the classification of that distinguished zoölogist, Milne-Edwards, lately presented by him as the expression of his present views of the natural affinities of animals. He is the only original investigator who has recently given his unqualified approbation to the primary divisions first proposed by Cuvier, admitting, of course, the rectifications among the group of secondary rank, rendered necessary by the progress of science, to which he has himself so largely contributed.

As to the classes adopted by Milne-Edwards, I have little to add to what I have already stated before, with reference to other classifications. Though no longer overruling the idea of plan, that of complication of structure has still too much influence with Milne-Edwards, inasmuch as it leads him to consider as classes, groups of animals which differ only in degree, and are therefore only orders.

Such are, no doubt, his classes of Molluscoids and those of Worms, besides the Myriapods and Arachnids. Respecting the Fishes, I refer to my remarks in the first section (p. 187) of this Chapter.

CLASSIFICATION OF MILNE-EDWARDS.

The following diagram is drawn from the author's Cours élémentaire d'Histoire naturelle, Paris, 1855, 1 vol. 12mo., 7th edit., in which he has presented the results of his latest investigations upon the classification of the Vertebrata and Articulata; the minor subdivisions of the Worms, Mollusks, and Zoophytes, however, are not considered in this work.[1]

I. OSTEOZOARIA, or VERTEBRATA.

Subbranch. *Allantoidians.*

CL. Mammalia. 1°. Monodelphya. *a.* Propria. *Ord.* Bimana, Quadrumana, Cheiroptera, Insectivora, Rodentia, Edentata, Carnivora, Amphibia, Pachydermata, Ruminantia. *b.* Pisciformia. *Ord.* Cetacea. 2°. Didelphya. *Ord.* Marsupialia, Monotremata.

CL. Birds. *Ord.* Rapaces, Passeres, Scansores, Gallinæ, Grallæ, and Palmipedes.

CL. Reptiles. *Ord.* Chelonia, Sauria, Ophidia.

Subbranch. *Anallantoidians.*

CL. Batrachians. *Ord.* Anura, Urodela, Perennibranchia, Cæciliæ.

CL. Fishes. 1°. Ossei. *Ord.* Acanthopterygii, Abdominales, Subbrachii, Apodes, Lophobranchii, and Plectognathi. 2°. Chondropterygii. *Ord.* Sturiones, Selachii, and Cyclostomi.

II. ENTOMOZOA, or ANNELLATA.

Subbranch. *Arthropoda.*

CL. Insecta. *Ord.* Coleoptera, Orthoptera, Nevroptera, Hymenoptera, Lepidoptera, Hemiptera, Diptera, Rhipiptera, Anoplura, and Thysanura.

CL. Myriapoda. *Ord.* Chilognatha and Chilopoda.

CL. Arachnids. *Ord.* Pulmonaria and Trachearia.

CL. Crustacea. 1°. Podophthalmia. *Ord.* Decapoda and Stomapoda. 2°. Edriophthalma. *Ord.* Amphipoda, Læmodipoda, and Isopoda. 3°. Branchiopoda. *Ord.* Ostrapoda, Phyllopoda, and Trilobitæ. 4°. Entomostraca. *Ord.* Copepoda, Cladocera, Siphonostoma, Lernæida, Cirripedia. 5°. Xiphosura.

Subbranch. *Vermes.*

CL. Annelids.

CL. Helminths.

CL. Turbellaria.

CL. Cestoidea.

CL. Rotatoria.

III. MALACOZOARIA, or MOLLUSCA.

Subbranch. *Mollusks proper.*

CL. Cephalopods.

CL. Pteropods.

CL. Gasteropods.

CL. Acephala.

Subbranch. *Molluscoids.*

CL. Tunicata.

CL. Bryozoa.

IV. ZOOPHYTES.

Subbranch. *Radiaria*, or *Radiata.*

CL. Echinoderms.

CL. Acalephs.

CL. Corallaria, or Polypi.

Subbranch. *Sarcodaria.*

CL. Infusoria.

CL. Spongiaria.

[1] Consult, for these, his recent papers upon Polyps, Mollusks, and Crustacea, in the Ann. des Sc. Nat.

CLASSIFICATION OF VON SIEBOLD AND STANNIUS.

This classification is adopted in the following work: SIEBOLD, (C. TH. v.,) and STANNIUS, (H.,) Lehrbuch der vergleichenden Anatomie, Berlin, 1845, 2 vols. 8vo. A second edition is now in press.

EVERTEBRATA.

I. PROTOZOA.

- CL. 1. Infusoria. *Ord.* Astoma and Stomatoda.
- CL. 2. Rhizopoda. *Ord.* Monosomatia and Polysomatia.

II. ZOOPHYTA.

- CL. 3. Polypi. *Ord.* Anthozoa and Bryozoa.
- CL. 4. Acalephae. *Ord.* Siphonophora, Discophora, Ctenophora.
- CL. 5. Echinodermata. *Ord.* Crinoidea, Asteroidea, Echinoidea, Holothurioidea, and Sipunculoidea.

III. VERMES.

- CL. 6. Helminthes. *Ord.* Cystici, Cestodes, Trematodes, Acanthocephali, Gordiacei, Nematodes.
- CL. 7. Turbellarii. *Ord.* Rhabdocœli, Dendrocœli.
- CL. 8. Rotatorii. Not subdivided into orders.
- CL. 9. Annulati. *Ord.* Apodes and Chætopodes.

Since the publication of the work quoted above, Siebold has introduced most important improvements in the classification of the Worms, and greatly increased our knowledge of these animals.

IV. MOLLUSCA.

- CL. 10. Acephala. *Ord.* Tunicata, Brachiopoda, Lamellibranchia.
- CL. 11. Cephalophora, Meck., (Gasteropoda.) *Ord.* Pteropoda, Heteropoda, Gasteropoda,
- CL. 12. Cephalopoda. Not subdivided into orders.

V. ARTHROPODA.

- CL. 13. Crustacea. *Ord.* Cirripedia, Siphonostoma, Lophyropoda, Phyllopoda, Pœcilopoda, Læmodipoda, Isopoda, Amphipoda, Stomapoda, Decapoda, Myriapoda.
- CL. 14. Arachnida. Orders without names.
- CL. 15. Insecta. *a.* Ametabola. *Ord.* Aptera. *b.* Hemimetabola; *Ord.* Hemiptera, Orthoptera. *c.* Holometabola. *Ord.* Diptera, Lepidoptera, Hymenoptera, Strepsiptera, Nevroptera, and Coleoptera.

VERTEBRATA.

VI. VERTEBRATA.

- CL. 16. Pisces. *Subclasses:* 1st. Leptocardii. 2d. Marsipobranchii. 3d. Elasmobranchii; *Ord.* Holocephali, Plagiostomi. 4th. Ganoidei; *Ord.* Chrondrostei, Holostei. 5th. Teleostei; *Ord.* Acanthopteri, Anacanthini, Pharyngognathi, Physostomi, Plectognathi, Lophobranchii. 6th. Dipnoi.
- CL. 17. Reptilia. *Subclasses:* 1st. Dipnoa; *Ord.* Urodela, Batrachia, Gymnophiona. 2d. Monopnoa: *a.* Streptostylica; *Ord.* Ophidia, Sauria. *b.* Monimostylica; *Ord.* Chelonia, Crocodila.
- CL. 18. Aves.
- CL. 19. Mammalia.

The subdivisions of the classes Pisces and Reptilia are taken from the second edition, published in 1854–1856, in which J. Müller's arrangement of the Fishes is adopted; that of the Reptiles is partly Stannius's own. The classes Aves and Mammalia, and the first volume of the second edition, are not yet out.

The most original feature of the classification of von Siebold is the adoption of the types Protozoa and Vermes, in the sense in which they are limited here. The type of Worms has grown out of the investigations of the helminthologists, who, too exclusively engaged with the parasitic Worms, have overlooked their relations to the other Articulata. On the other hand, the isolation in which most entomologists have remained from the zoölogists in general, has no doubt had its share in preventing an earlier thorough comparison of the Worms and the larval conditions of Insects, without which the identity of type of the Worms, Crustacea, and Insects can hardly be correctly appreciated. Concerning the classes[1] adopted by von Siebold and Stannius, I have nothing to remark that has not been said already.

CLASSIFICATION OF R. LEUCKART.

The classification of Leuckart is compiled from the following work: LEUCKART, (R.,) Ueber die Morphologie und die Verwandtschaftsverhältnisse der wirbellosen Thiere, Braunschweig, 1848, 1 vol. 8vo.

I. COELENTERATA, Lkt.
- CL. 1. Polypi. *Ord.* Anthozoa and Cylicozoa (Lucernaria.)
- CL. 2. Acalephae. *Ord.* Discophoræ and Ctenophoræ.

II. ECHINODERMATA, Lkt.
- CL. 3. Pelmatozoa, Lkt. *Ord.* Cystidea and Crinoidea.
- CL. 4. Actinozoa, Latr. *Ord.* Echinida and Asterida.
- CL. 5. Scytodermata, Brmst. *Ord.* Holothuriæ and Sipunculida.

III. VERMES.
- CL. 6. Anenterati, Lkt. *Ord.* Cestodes and Acanthocephali. (Helminthes, *Burm.*)
- CL. 7. Apodes, Lkt. *Ord.* Nemertini, Turbellarii, Trematodes, and Hirudinei. (Trematodes, *Burm.*)
- CL. 8. Ciliati, Lkt. *Ord.* Bryozoa and Rotiferi.
- CL. 9. Annelides. *Ord.* Nematodes, Lumbricini, and Branchiati. (Annulati, *Burm.*, excl. Nemertinis et Hirudineis.)

IV. ARTHROPODA.
- CL. 10. Crustacea. *Ord.* Entomostraca (Neusticopoda Car.) and Malacostraca.
- CL. 11. Insecta. *Ord.* Myriapoda, Arachnida, (Acera, Latr.,) and Hexapoda.

V. MOLLUSCA, Cuv. (Palliata, Nitzsch.)
- CL. 12. Tunicata. *Ord.* Ascidiæ (Tethyes Sav.) and Salpæ (Thalides Sav.) } Leuckart is somewhat inclined to consider the Tunicata not simply as a class, but even as another great type or branch, intermediate between Echinoderms and Worms.
- CL. 13. Acephala. *Ord.* Lamellibranchiata (Cormopoda Nitzsch, Pelecypoda Car.) and Brachiopoda.
- CL. 14. Gasteropoda. *Ord.* Heterobranchia, (Pteropoda, Inferobranchia, and Tectibranchia,) Dermatobranchia, (Gymnobranchia and Phlebenterata,) Heteropoda, Ctenobranchia, Pulmonata, and Cyclobranchia.
- CL. 15. Cephalopoda.

VI. VERTEBRATA. (Not considered.)

[1] The names of the types, Protozoa and Vermes, are older than their limitation in the classification of Siebold. That of Protozoa, first introduced by Goldfuss, has been used in various ways for nearly half a century, while that of Worms was first adopted by Linnæus, as a great division of the animal kingdom, but in a totally different sense.

I need not repeat here what I have already stated, in the first section, respecting the primary divisions adopted by Siebold and Leuckart. As to the classes, I may add that his three classes of Echinoderms exhibit only ordinal characters. Besides Birds and Cephalopods, there is not another class so well defined, and so little susceptible of being subdivided into minor divisions presenting any thing like class characters, as that of Echinoderms. Their systems of organs are so closely homological, (compare p. 183,) that the attempt here made by Leuckart, of subdividing them into three classes, can readily be shown to rest only upon the admission, as classes, of groups which exhibit only ordinal characters, namely, different degrees of complication of structure. With reference to the classes of Worms, the same is equally true, as shown above. The arrangement of these animals proposed by Burmeister is certainly more correct than those of von Siebold and of Leuckart, inasmuch as he refers already correctly the Rotifera to the class of Crustacea, and does not, like Leuckart, associate the Bryozoa with the Worms. I agree, however, with Leuckart respecting the propriety of removing the Nemertini and Hirudinei from among the true Annelides. Again, Burmeister appreciates also more correctly the position of the whole type of Worms, in referring them, with de Blainville, to the branch of Articulata.

The common fault of all the anatomical classifications which have been proposed since Cuvier consists, first, in having given up, to a greater or less extent, the fundamental idea of the plan of structure, so beautifully brought forward by Cuvier, and upon which he has insisted with increased confidence and more and more distinct consciousness, ever since 1812; and, second, in having allowed that of complication of structure frequently to take the precedence over the more general features of plan, which, to be correctly appreciated, require, it is true, a deeper insight into the structure of the whole animal kingdom than is needed merely for the investigation of anatomical characters in single types.

Yet, if we take a retrospective glance at these systems, and especially consider the most recent ones, it must be apparent to those who are conversant with the views now obtaining in our science, that, after a test of half a century, the idea of the existence of branches, characterized by different plans of structure, as expressing the true relations among animals, has prevailed over the idea of a gradated scale including all animals in one progressive series. When it is considered that this has taken place amidst the most conflicting views respecting classification, and even in the absence of any ruling principle, it must be acknowledged that this can be only owing to the internal truth of the views first propounded by Cuvier. We recognize in the classifications of Siebold, Leuckart, and others the triumph of the great conception of the French naturalist, even though their systems differ greatly from his, for the question whether there are four or

more great plans, limited in this or any other way, is not a question of principle, but one involving only accuracy and penetration in the investigation; and I maintain that the first sketch of Cuvier, with all its imperfections of details, presents a picture of the essential relations existing among animals truer to nature than the seemingly more correct classifications of recent writers.

SECTION V.

PHYSIOPHILOSOPHICAL SYSTEMS.

About the time that Cuvier and the French naturalists were tracing the structure of the animal kingdom, and attempting to erect a natural system of Zoölogy upon this foundation, there arose in Germany a school of philosophy, under the lead of Schelling, which extended its powerful influence to all the departments of physical science. Oken, Kieser, Bojanus, Spix, Huschke, and Carus are the most eminent naturalists who applied the new philosophy to the study of Zoölogy. But no one identified his philosophical views so completely with his studies in natural history as Oken.

Now that the current is setting so strongly against every thing which recalls the German physiophilosophers and their doings, and it has become fashionable to speak ill of them, it is an imperative duty for the impartial reviewer of the history of science to show how great and how beneficial the influence of Oken has been upon the progress of science in general and of Zoölogy in particular. It is moreover easier, while borrowing his ideas, to sneer at his style and his nomenclature, than to discover the true meaning of what is left unexplained in his mostly paradoxical, sententious, or aphoristical expressions; but the man who has changed the whole method of illustrating comparative Osteology, — who has carefully investigated the embryology of the higher animals, at a time when few physiologists were paying any attention to the subject, who has classified the three kingdoms of nature upon principles wholly his own, who has perceived thousands of homologies and analogies among organized beings entirely overlooked before, who has published an extensive treatise of natural history containing a condensed account of all that was known at the time of its publication, who has conducted for twenty-five years the most extensive and most complete periodical review of the natural sciences ever published, in which every discovery made during a quarter of a century is faithfully recorded, the man who inspired every student with an ardent love for science, and with admiration for his teacher, — that man will never be forgotten, nor can the services he has rendered to science be overlooked, so long as thinking is connected with investigation.

CLASSIFICATION OF OKEN.

The following diagram of Oken's classification is compiled from his Allgemeine Naturgeschichte für alle Stände, Stuttgardt, 1833–1842, 14 vols. 8vo.; vol. 1, p. 5. The changes this system has undergone may be ascertained by comparing his Lehrbuch der Naturphilosophie, Iena, 1809–1811, 3 vols. 8vo.; 2d edit., Iena, 1831; 3d edit., Zürich, 1843; Engl. Ray Society, London, 1847, 1 vol. 8vo. — Lehrbuch der Naturgeschichte, Leipzig, 1813; Weimar, 1815 and 1825, 8vo. — Handbuch der Naturgeschichte zum Gebrauch bei Vorlesungen, Nürnberg, 1816–1820, 8vo. — Naturgeschichte für Schulen, Leipzig, 1820, 1 vol. 8vo., and various papers in the Isis.

1st Grade. INTESTINAL ANIMALS; also called *Body*-animals and *Touch*-animals. Only one cavity; no head with a brain, only the lowest sense perfect, intestines and skin organs, but no flesh, that is no bones, muscles, or nervous marrow = *Invertebrata.*

Characterized by the development of the vegetative systems of organs, which are those of digestion, circulation, and respiration. Hence —

Cycle I. *Digestive Animals.* = Radiata. Essential character: no development beyond an intestine.

- CL. 1. Infusoria, (Stomach animals.) Mouth with cilia only, to vibrate.
- CL. 2. Polypi, (Intestine animals.) Mouth with lips and tentacles, to seize.
- CL. 3. Acalephae, (Lacteal animals.) Body traversed by tubes similar to the lymphatic vessels.

Cycle II. *Circulative Animals.* = Mollusks. Essential character: intestine and vessels.

- CL. 4. Acephala, (Biauriculate animals.) Membranous heart with two auricles.
- CL. 5. Gasteropoda, (Uniauriculate animals.) Membranous heart with one auricle.
- CL. 6. Cephalopoda, (Bicardial animals.) Two hearts.

Cycle III. *Respirative Animals.* = Articulata. Essential character: intestine, vessels, and spiracles.

- CL. 7. Worms, (Skin animals.) Respire with the skin itself, or part of it, no articulated feet.
- CL. 8. Crustacea, (Branchial animals.) Gills or air tubes arising from the horny skin.
- CL. 9. Insects, (Tracheal animals.) Tracheæ internally, gills externally as wings.

2d Grade. FLESH ANIMALS; also called *Head*-animals. = *Vertebrata.* Two cavities of the body, surrounded by fleshy walls, (bones and muscles,) inclosing nervous marrow and intestines. Head with brain; higher senses developed. Characterized by the development of the animal systems, namely, the skeleton, the muscles, the nerves, and the senses.

Cycle IV. *Carnal Animals proper.* Senses not perfected.

- CL. 10. Fishes, (*Bone*-animals.) Skeleton predominating, very much broken up; muscles white, brain without gyri, tongue without bone, nose not perforated, ear concealed, eyes without lids.
- CL. 11. Reptiles, (*Muscle*-animals.) Muscles red, brain without convolutions, nose perforated, ear without external orifice, eyes immovable with imperfect lids.
- CL. 12. Birds, (*Nerve*-animals.) Brain with convolutions, ears open, eyes immovable, lids imperfect.

Cycle V. *Sensual Animals.* All anatomical systems, and the senses perfected.

- CL. 13. Mammalia, (*Sense*-animals.) Tongue and nose fleshy, ears open, mostly with a conch, eyes movable, with two distinct lids.

The principles laid down by Oken, of which this classification is the practical result for Zoölogy, may be summed up in the following manner: The grades or great types of Animals are determined by their anatomical systems, such as the body and head; or the intestines, and the flesh and senses. Hence two grades in the animal kingdom. Animals are, as it were, the dismembered body of man made alive. The classes of animals are the special representation in living forms of the anatomical systems of the highest being in creation.

Man is considered, in this system, not only as the key of the whole animal kingdom, but also as the standard measure of the organization of animals. There exists nothing in the animal kingdom which is not represented in higher combinations in Man. The existence of several distinct plans of structure among animals is virtually denied. They are all built after the pattern of Man; the differences among them consist only in their exhibiting either one system only, or a larger or smaller number of systems of organs of higher or lower physiological importance, developed either singly, or in connection with one another, in their body. The principles of classification of both Cuvier and Ehrenberg are here entirely negatived. The principle of Cuvier, who admits four different plans of structure in the animal kingdom, is, indeed, incompatible with the idea that all animals represent only the organs of Man. The principle of Ehrenberg, who considers all animals as equally perfect, is as completely irreconcilable with the assumption that all animals represent an unequal sum of organs; for, according to Oken, the body of animals is, as it were, the analyzed body of Man, the organs of which live singly, or in various combinations as independent animals. Each such combination constitutes a distinct class. The principle upon which the orders are founded has already been explained above, (Chap. II., Sect. III., p. 154.)

There is something very taking in the idea that Man is the standard of appreciation of all animal structures. But all the attempts which have thus far been made to apply it to the animal kingdom as it exists, must be considered as complete failures. In his different works, Oken has successively identified the systems of organs of Man with different groups of animals, and different authors, who have adopted the same principle of classification, have identified them in still different ways. The impracticability of such a scheme must be obvious to any one who has satisfied himself practically of the existence of different plans of structure in the organization of animals. Yet, the unsoundness of the general principle of the classifications of the physiophilosophers should not render us blind to all that is valuable in their special writings. The works of Oken in particular teem with original suggestions respecting the natural affinities of animals; and his thorough acquaintance with every investigation of his predecessors and contemporaries shows him to have been one of the most learned zoölogists of this century.

CLASSIFICATION OF FITZINGER.

This diagram is extracted from Fitzinger's Systema Reptilium, Vindobonæ, 1843, 1 vol. 8vo.

I. Provincia. EVERTEBRATA.
Animalia systematum anatomicorum vegetativorum gradum evolutionis exhibentia.

A. Gradus evolutionis systematum physiologicorum vegetativorum.

I. Circulus. GASTROZOA.
Evolutio systematis nutritionis.

a. Evolutio prævalens systematis digestionis.	*b.* Evolutio prævalens systematis circulationis.	*c.* Evolutio prævalens systematis respirationis.
Cl. 1. Infusoria.	Cl. 2. Zoophyta.	Cl. 3. Acalephae.

II. Circulus. PHYSIOZOA.
Evolutio systematis generationis.

Cl. 4. Vermes.	Cl. 5. Radiata.	Cl. 6. Annulata.

B. Gradus evolutionis systematum physiologicorum animalium.

III. Circulus. DERMATOZOA.
Evolutio systematis sensibilitatis.

Cl. 7. Acephala.	Cl. 8. Cephalopoda.	Cl. 9. Mollusca.

IV. Circulus. ARTHROZOA.
Evolutio systematis motus.

Cl. 10. Crustacea.	Cl. 11. Arachnoidea.	Cl. 12. Insecta.

II. Provincia. VERTEBRATA.
Animalia systematum anatomicorum animalium gradum evolutionis exhibentia.

A. Gradus evolutionis systematum physiologicorum vegetativorum.
a. Evolutio systematis nutritionis, simulque ossium: . . Cl. 13. Pisces.
b. Evolutio systematis generationis, simulque musculorum: Cl. 14. Reptilia.

B. Gradus evolutionis systematum physiologicorum animalium.
c. Evolutio systematis sensibilitatis, simulque nervorum: Cl. 15. Aves.
d. Evolutio systematis motus, simulque sensuum: . . . Cl. 16. Mammalia.

The fundamental idea of the classification of Fitzinger is the same as that upon which Oken has based his system. The higher divisions, called by him provinces, grades, and cycles, as well as the classes and orders, are considered as representing either some combination of different systems of organs, or some particular system of organs, or some special organ. His two highest groups (provinces) are the Evertebrata and Vertebrata. The Evertebrata represent the systems of the vegetative organs, and the Vertebrata those of the animal organs, as the Gut-

animals and the Flesh-animals of Oken. Instead, however, of adopting, like Oken, anatomical names for his divisions, Fitzinger employs those most generally in use. His subdivisions or grades of these two primary groups are based upon a repetition of the same differences, within their respective limits. The Invertebrata, in which the vegetative organs prevail, are contrasted with those in which the animal organs prevail, and the same distinction is again drawn among the Vertebrata. Each of these embraces two circles founded upon the development of one particular system of organs, etc. It cannot be expected that the systems founded upon such principles should present a closer agreement with one another than those which are based upon anatomical differences; yet I would ask, what becomes of the principle itself, if its advocates cannot even agree upon what anatomical systems of organs their classes are founded? According to Oken, the Mollusks (Acephala, Gasteropoda, and Cephalopoda) represent the system of circulation, at least in the last edition of his system he views them in that light, whilst Fitzinger considers them as representing the system of sensibility. Oken identifies the Articulata (Worms, Crustacea, and Insects) with the system of respiration, Fitzinger with that of motion, with the exception of the Worms, including Radiata, which he parallelizes with the system of reproduction, etc. Such discrepancies must shake all confidence in these systems, though they should not prevent us from noticing the happy comparisons and suggestions, to which the various attempts to classify the animal kingdom in this way have led their authors. It is almost superfluous to add, that, great as the disagreement is between the systems of different physiophilosophers, we find quite as striking discrepancies between the different editions of the system of the same author.

The principle of the subdivision of the classes among Invertebrata is here exemplified from the Radiata, (Echinodermata.) Each series contains three orders.

1st Series.	2d Series.	3d Series.
Evolutio prævalens systematis digestionis.	Evolutio prævalens systematis circulationis.	Evolutio prævalens systematis respirationis.
Asteroidea.	Echinodea.	Scytodermata (Holothurioids.)
1. Encrinoidea. 2. Comatulina. 3. Asterina.	1. Aprocta. 2. Echinina. 3. Spatangoidea.	1. Synaptoidea. 2. Holothurioidea. 3. Pentactoidea.

In Vertebrata, each class has five series and each series three orders; so in Mammalia, for example:—

1st Series.	2d Series.	3d Series.	4th Series.	5th Series.
Evolutio prævalens sensus tactus.	Evolutio prævalens sensus gustus.	Evolutio prævalens sensus olfactus.	Evolutio prævalens sensus auditus.	Evolutio prævalens sensus visus.
Cetacea.	Pachydermata.	Edentata.	Unguiculata.	Primates.
1. Balanodea.	1. Phocina.	1. Monotremata.	1. Glires.	1. Chiropteri.
2. Delphinodea.	2. Obesa.	2. Lipodonta.	2. Bruta.	2. Hemipitheci.
3. Sirenia.	3. Ruminantia.	3. Tardigrada.	3. Feræ.	3. Anthropomorphi.

Instead of considering the orders as founded upon a repetition of the characters of higher groups, as Oken would have it, Fitzinger adopts series, as founded upon that idea, and subdivides them further into orders, as above. These series, however, have still less reference to the systems of organs, which they are said to represent, than either the classes or the higher divisions of the animal kingdom. In these attempts to arrange minor groups of animals into natural series, no one can fail to perceive an effort to adapt the frames of our systems to the impression we receive from a careful examination of the natural relations of organized beings. Everywhere we notice such series; sometimes extending only over groups of species, at other times embracing many genera, entire families, nay, extending frequently to several families. Even the classes of the same branch may exhibit more or less distinctly such a serial gradation. But I have failed, thus far, to discover the principle to which such relations may be referred, as far as they do not rest upon complication of structure,[1] or upon the degree of superiority or inferiority of the features upon which the different kinds of groups are themselves founded. Analogy plays also into the series, but before the categories of analogy have been as carefully scrutinized as those of affinity, it is impossible to say within what limits this takes place.

CLASSIFICATION OF McLEAY.

The great merit of the system of McLeay,[2] and in my opinion it has no other claim to our consideration, consists in having called prominently the attention of naturalists to the difference between two kinds of relationship, almost universally confounded before: *affinity* and *analogy*. Analogy is shown to consist in the repetition of similar features in groups otherwise remote, as far as their anatomical characters are concerned, whilst affinity is based upon similarity in the structural relations. On account of the similarity of their locomotion, Bats, for instance, may be considered as analogous to Birds; Whales are analogous to Fishes on account of the similarity of their form and their aquatic mode of life; whilst both Bats and Whales are allied to one another and to other Mammalia on account of the identity of the most characteristic features of their structure. This important distinction cannot fail to lead to interesting results. Thus far, however, it has only produced fanciful comparisons from those who first traced it out. It is assumed, for instance, by McLeay, that all animals of one group must be analogous to

[1] Compare Chap. II., Sect. 3, p. 153.

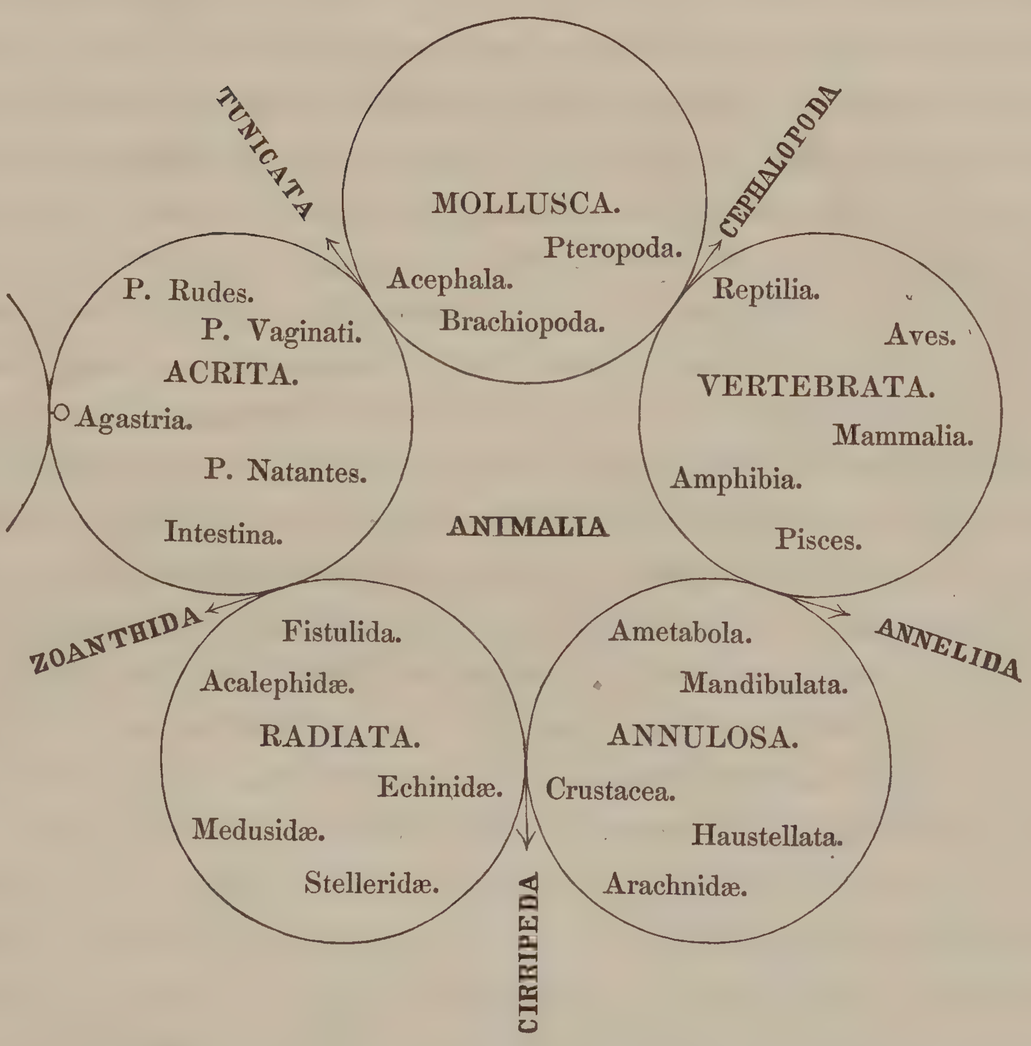
[2] I have introduced the classification of McLeay in this section, not because of any resemblance to those of the German physiophilosophers, but on account of its general character, and because it is based upon an ideal view of the affinities of animals.

those of every other group, besides forming a circle in themselves; and in order to carry out this idea, all animals are arranged in circular groups, in such a manner as to bring out these analogies, whilst the most obvious affinities are set aside to favor a preconceived view. But that I may not appear to underrate the merits of this system, I will present it in the very words of its most zealous admirer and self-complacent expounder, the learned William Swainson.[1]

"The Horæ Entomologicæ,[2] unluckily for students, can only be thoroughly understood by the adept, since the results and observations are explained in different parts; the style is somewhat desultory, and the groups, for the most part, are rather indicated than defined. The whole, in short, is what it professes to be, more a rough sketch of the leading peculiarities of the great divisions of animals, and the manner in which they are probably connected, than an accurate determination of the groups themselves, or a demonstration of their real affinities. More than this, perhaps, could not have been expected, considering the then state of science, and the herculean difficulties which the author had to surmount. The work in question has now become exceedingly scarce, and this will be an additional reason with us for communicating occasional extracts from it to the reader. Mr. McLeay's theory will be best understood by consulting his diagram; for he has not, as we have already remarked, defined any of the vertebrated groups. Condensing, however, the result of his remarks, we shall state them as resolvable into the following propositions: 1. That the natural series of animals is continuous, forming, as it were, a circle, so that, upon commencing at any one given point, and thence tracing all the modifications of structure, we shall be imperceptibly led, after passing through numerous forms, again to the point from which we started; 2. That no groups are natural which do not exhibit such a circular series; 3. That the primary divisions of every large group are ten, five of which are composed of comparatively large circles, and five of smaller: these latter being termed osculant, and being intermediate between the former, which they serve to connect; 4. That there is a tendency in such groups as are placed at the opposite points of a circle of affinity 'to meet each other;' 5. That *one* of the five larger groups into which every natural circle is divided, 'bears a resemblance to all the rest, or, more strictly speaking, consists of types which represent those of each of the four other groups, together with a type peculiar to itself.' These are the chief and leading principles which Mr. McLeay considers as belonging to the natural system. We shall now copy his diagram, or table of the animal kingdom, and then endeavor, with this help, to explain the system more in detail."

[1] SWAINSON, (W.,) A Treatise of the Geography and Classification of Animals, London, 1835, 1 vol. 12mo., p. 201–205.

[2] MCLEAY, (W. S.,) Horæ Entomologicæ, or Essays on the Annulose Animals, London, 1819–21, 2 vols. 8vo.



"We must, in the first instance, look to the above tabular disposition of all animals, as forming themselves collectively into one great circle, which circle touches or blends into another, composed of plants, by means of the 'least organized beings of the vegetable kingdom.' Next we are to look to the larger component parts of this great circular assemblage. We find it, in accordance with the third proposition, to exhibit five great circles, composed of the MOLLUSCA, or shellfish; ACRITA, or polyps; RADIATA, or star-fish; ANNULOSA, or insects; and VERTEBRATA, or vertebrated animals; each passing or blending into each other, by means of five other groups of animals, much smaller, indeed, in their extent, but forming so many connecting or osculant circles.[1] The number, therefore, as many erroneously suppose, is not five, but ten. This is quite obvious; and our opinion on this point is confirmed by the author himself, in the following passage, when alluding to his remarks upon the whole:—'The foregoing observations, I am well aware, are far from accurate, but they are sufficient to prove that there are five great circular groups in the animal kingdom, each of which possesses a peculiar structure; and that

[1] In the original diagram, as in that above, these five smaller circles are not represented graphically, but merely indicated by the names arranged like rays between the five large circles.

these, when connected by means of five smaller osculant groups, compose the whole province of Zoölogy.' Now these smaller osculant groups are to be viewed as circles, for, as it is elsewhere stated, 'every natural group is a circle, more or less complete.' This, in fact, is the third general principle of Mr. McLeay's system, and he has exemplified his meaning of a natural group in the above diagram, where all animals are arranged under five large groups or circles, and five smaller ones. Let us take one of these groups, the Vertebrata: does that form a circle of itself? Yes; because it is intimated that the Reptiles (*Reptilia*) pass into the Birds, (*Aves*,) these again into the Quadrupeds, (*Mammalia*,) Quadrupeds unite with the Fishes, (*Pisces*,) these latter with the amphibious Reptiles, and the Frogs bring us back again to the Reptiles, the point from whence we started. Thus, the series of the vertebrated group is marked out and shown to be circular; therefore, it is a natural group. This is an instance where the circular series can be traced. We now turn to one where the series is imperfect, but where there is a decided tendency to a circle: this is the Mollusca. Upon this group our author says, 'I have by no means determined the circular disposition to hold good among the Mollusca; still, as it is equally certain that this group of animals is as yet the least known, it may be improper, at present, to conclude that it forms any exception to the rule; it would even seem unquestionable that the Gasteropoda of Cuvier return into themselves, so as to form a circular group; but whether the Acephala form one or two such, is by no means accurately ascertained, though enough is known of the Mollusca to incline us to suspect that they are no less subjected, in general, to a circular disposition than the four other great groups.' This, therefore, our author considers as one of those groups which, without actually forming a circle, yet evinces a disposition to do so; and it is therefore presumed to be a natural group. But, to illustrate this principle farther, let us return to the circle of Vertebrata. This, as we see by the diagram, contains five minor groups, or circles, each of which is again resolvable into five others, regulated precisely in the same way. The class Aves, for example, is first divided into rapacious birds, (*Raptores*,) perching birds, (*Insessores*,) gallinaceous birds, (*Rasores*,) wading birds, (*Grallatores*,) and swimming birds (*Natatores*); and the proof of this class being a natural group is, in all these divisions blending into each other at their confines, and forming a circle. In this manner we proceed, beginning with the higher groups, and descending to the lower, until at length we descend to genera, properly so called, and reach, at last, the species; every group, whether large or small, forming a circle of its own. Thus there are circles within circles, 'wheels within wheels,'—an infinite number of complicated relations; but all regulated by one simple and uniform principle,—that is, the circularity of every group."

The writer who can see that the Quadrupeds unite with the Fishes, and the like, and yet says that Cuvier "was totally unacquainted with the very first principles of the natural system," hardly deserves to be studied in our days.

The attempt at representing graphically the complicated relations which exist among animals has, however, had one good result; it has checked, more and more, the confidence in the uniserial arrangement of animals, and led to the construction of many valuable maps exhibiting the multifarious relations which natural groups, of any rank, bear to one another.

SECTION VI.

EMBRYOLOGICAL SYSTEMS.

Embryology, in the form it has assumed within the last fifty years, is as completely a German science as the "Naturphilosophie." It awoke to this new activity contemporaneously with the development of the Philosophy of Nature. It would hardly be possible to recognize the leading spirit in this new development, from his published works; but the man whom Pander and K. E. von Baer acknowledge as their master must be considered as the soul of this movement, and this man is Ignatius Döllinger. It is with deep gratitude I remember, for my own part, the influence that learned and benevolent man had upon my studies and early scientific application, during the four years I spent in his house, in Munich, from 1827 to 1831; to him I am indebted for an acquaintance with what was then known of the development of animals, prior to the publication of the great work of Baer; and from his lectures I first learned to appreciate the importance of Embryology to Physiology and Zoölogy. The investigations of Pander[1] upon the development of the chicken in the egg, which have opened the series of those truly original researches in Embryology of which Germany may justly be proud, were made under the direction and with the coöperation of Döllinger, and were soon followed by the more extensive works of Rathke and Baer, whom the civilized world acknowledges as the founders of modern Embryology.

The principles of classification propounded by K. E. von Baer seem never to have been noticed by systematic writers, and yet they not only deserve the most careful consideration, but it may fairly be said that no naturalist besides Cuvier has exhibited so deep an insight into the true character of a natural system,

[1] PANDER, Beiträge zur Entwickelungsgeschichte des Hühnchens im Eie, Würzburg, 1817, 1 vol. fol.

supported by such an extensive acquaintance with the subject, as this great embryologist has in his "Scholien und Corallarien zu der Entwickelungsgeschichte des Hühnchens im Eie."[1] These principles are presented in the form of general proportions, rather than in the shape of a diagram with definite systematic names, and this may explain the neglect which it has experienced on the part of those who are better satisfied with words than with thoughts. A few abstracts, however, may show how richly the perusal of his work is likely to reward the reader.

The results at which K. E. von Baer had arrived by his embryological investigations, respecting the fundamental relations existing among animals, differed considerably from the ideas then prevailing. In order, therefore, to be correctly understood, he begins, with his accustomed accuracy and clearness, to present a condensed account of those opinions with which he disagreed, in these words:—

"Few views of the relations existing in the organic world have received so much approbation as this: that the higher animal forms, in the several stages of the development of the individual, from the beginning of its existence to its complete formation, correspond to the permanent forms in the animal series, and that the development of the several animals follows the same laws as those of the entire animal series; that consequently the more highly organized animal, in its individual development, passes in all that is essential through the stages that are permanent below it, so that the periodical differences of the individual may be reduced to the differences of the permanent animal forms."

Next, in order to have some standard of comparison with his embryological results, he discusses the relative position of the different permanent types of animals, as follows:—

"It is especially important that we should distinguish between the degree of perfection in the animal structure and the type of organization. The degree of perfection of the animal structure consists in the greater or less heterogeneousness of the elementary parts, and the separate divisions of a complicated apparatus,—in one word, in the greater histological and morphological differentiation. The more uniform the whole mass of the body is, the lower the degree of perfection; it is a stage higher when nerve and muscle, blood and cellular tissue, are sharply distinguished. In proportion to the difference between these parts, is the development of the animal life in its different tendencies; or, to express it more accurately, the more the animal life is developed in its several tendencies, the more heterogeneous are the elementary parts which this life brings into action. The same is true of the single parts of any apparatus. That organ-

[1] Ueber Entwickelungsgeschichte der Thiere, Beobachtung und Reflexion von Dr. Karl Ernst von Baer, Königsberg, 1828, 4to. — See also Acta Nova Acad. Leop. Cæsar, vol. 13, and Meckel's Arch., 1826.

ization is higher in which the separate parts of an entire system differ more among themselves, and each part has greater individuality, than that in which the whole is more uniform. I call type, the relations of organic elements and organs, as far as their position is concerned. This relation of position is the expression of certain fundamental connections in the tendency of the individual relations of life; as, for instance, of the receiving and discharging poles of the body. The type is altogether distinct from the degree of perfection, so that the same type may include many degrees of perfection, and, *vice versâ*, the same degree of perfection may be reached in several types. The degree of perfection, combined with the type, first determines those great animal groups which have been called classes.[1] The confounding of the degree of perfection with the type of organization seems the cause of much mistaken classification, and in the evident distinction between these two relations we have sufficient proof that the different animal forms do not present one uniserial development, from the Monad up to Man."

The types he has recognized are:—

I. *The Peripheric Type.* The essential contrasts in this type are between the centre and the periphery.[2] The organic functions of life are carried on in antagonistic relations from the centre to the circumference. Corresponding to this, the whole organization radiates around a common centre. There exists besides only the contrast between above and below, but in a weaker degree; that between right and left, or before and behind, is not at all noticeable, and the motion is therefore undetermined in its direction. As the whole organization radiates from one focus, so are the centres of all the organic systems arranged, ring-like, around it, as, for instance, the stomach, the nerves and vessels, (if these parts are developed,) and the branches extending from them into the rays. What we find in one ray is repeated in every other, the radiation being always from the centre outwards, and every ray bearing the same relation to it.

II. *The Longitudinal Type*, as observed in the Vibrio, the Filaria, the Gordius, the Nais, and throughout the whole series of articulated animals. The contrast between the receiving and the discharging organs, which are placed at the two ends of the body, controls the whole organization. The mouth and the anus are

[1] From this statement it is plain that Baer has a very definite idea of the plan of structure, and that he has reached it by a very different road from that of Cuvier. It is clear, also, that he understands the distinction between a plan and its execution. But his ideas respecting the different features of structure are not quite so precise. He does not distinguish, for instance, between the complication of structure as determining the relative rank of the orders, and the different ways in which, and the different means with which the plans are executed, as characteristic of the classes.

[2] Without translating verbatim the descriptions Baer gives of his types, which are greatly abridged here, they are reproduced as nearly as possible in his own words.

always at opposite ends, and usually also the sexual organs, though their opening is sometimes farther forward; this occurs, however, more frequently in the females, in which these organs have a double function, than in the males. When both sexual organs are removed from the posterior extremity, the opening in the female usually lies farther forward than in the male. So is it in the Myriapods and the Crabs. The Leeches and Earthworms present a rare exception. The receptive pole being thus definitely fixed, the organs of senses, as instrumental to the receptivity of the nervous system, early reach an important degree of perfection. The intestinal canal, as well as the vascular stems and the nervous system, extend through the whole length of the body, and all organic motion in these animals has the same prevailing direction. Only subordinate branches of these organs arise laterally, and chiefly wherever the general contrast, manifested in the whole length is repeated in such a manner that, for each separate segment, the same contrast arises anew, in connection with the essential elements of the whole organism. Hence the tendency in these animals to divide into many segments in the direction of the longitudinal axis of the body. In the true Insects, undergoing metamorphosis, these segments unite again into three principal regions, in the first of which the life of the nerves prevails; in the second, motion; in the third, digestion; though neither of the three regions is wholly deprived of any one of these functions. Besides the opposition between before and behind, a less marked contrast is observed in a higher stage of development between above and below. A difference between right and left forms a rare exception, and is generally wanting. Sensibility and irritability are particularly developed in this series. Motion is active, and directed more decidedly forward, in proportion as the longitudinal axis prevails. When the body is contracted as in spiders and crabs, its direction is less decided. The plastic organs are little developed; glands, especially, are rare, and mostly replaced by simple tubes.

III. *The Massive Type.* We may thus call the type of Mollusks, for neither length nor surface prevails in them, but the whole body and its separate parts are formed rather in round masses which may be either hollow or solid. As the chief contrast of their structure is not between the opposite ends of the body, nor between the centre and periphery, there is almost throughout this type an absence of symmetry. Generally the discharging pole is to the right of the receptive one. The discharging pole, however, is either near the receptive one, or removed from it, and approximated to the posterior extremity of the body. As the tract of the digestive apparatus is always determined by these two poles, it is more or less arched; in its simplest form it is only a single arch, as in Plumatella. When that canal is long, it is curled up in a spiral in the centre, and the spiral probably has its definite laws. For instance, the anterior part of the alimentary canal appears to be always placed under the posterior. The principal currents

of blood are also in arches, which do not coincide with the medial line of the body. The nervous system consists of diffused ganglia, united by threads, the larger ones being around the œsophagus. The nervous system and the organs of sense appear late; the motions are slow and powerless.

IV. *The Vertebrate Type.* This is, as it were, composed of the preceding types, as we distinguish an animal and a vegetative system of the body, which, though influencing one another in their development, have singly a peculiar typical organization. In the animal system, the articulation reminds us of the second type, and the discharging and receiving organs are also placed at opposite ends. There is, however, a marked difference between the Articulates and the Vertebrates, for the animal system of the Vertebrates is not only doubled along the two sides, but at the same time upwards and downwards, in such a way that the two lateral walls which unite below circumscribe the vegetative system, while the two tending upward surround a central organ of the animal life, the brain and spinal marrow, which is wanting in Invertebrates. The solid frame represents this type most completely, as from its medial axis, the backbone, there arise upward arches which close in an upper crest, and downward arches which unite, more or less, in a lower crest. Corresponding to this we see four rows of nervous threads along the spinal marrow, which itself contains four strings, and a quadripartite grey mass. The muscles of the trunk form also four principal masses, which are particularly distinct in the Fishes. The animal system is therefore doubly symmetrical in its arrangement. It might easily be shown how the vegetative systems of the body correspond to the type of Mollusks, though influenced by the animal system.

From the illustrations accompanying this discussion of the great types or branches of the animal kingdom, and still more from the paper published by K. E. von Baer in the Nova Acta,[1] it is evident, that he perceived more clearly and earlier than any other naturalist, the true relations of the lowest animals to their respective branches. He includes neither Bryozoa nor Intestinal Worms among Radiata, as Cuvier, and after him so many modern writers, did, but correctly refers the former to the Mollusks and the latter to the Articulates.

Comparing these four types with the embryonic development, von Baer shows that there is only a general similarity between the lower animals and the embryonic stages of the higher ones, arising mainly from the absence of differentiation in the body, and not from a typical resemblance. The embryo does not pass from one type to the other; on the contrary, the type of each animal is defined from the

[1] Beiträge zur Kenntniss der niedern Thiere, Nova Acta Academiæ Naturæ Curiosorum, vol. 13, Part 2, 1827, containing seven papers, upon Aspidogaster, Distoma, and others, Cercaria, Nitzschia, Polystoma, Planaria, and the general affinities of all animals. These "Beiträge," and the papers in which Cuvier characterized for the first time the four great types of the animal kingdom, are among the most important contributions to general Zoölogy ever published.

beginning and controls the whole development. The embryo of the Vertebrate is a Vertebrate from the beginning, and does not exhibit at any time a correspondence with the Invertebrates. The embryos of Vertebrates do not pass in their development through other permanent types of animals. The fundamental type is first developed, afterwards more and more subordinate characters appear. From a more general type, the more special is manifested, and the more two forms of animals differ, the earlier must their development be traced back to discern an agreement between them. It is barely possible that in their first beginning all animals are alike and present only hollow spheres, but the individual development of the higher animals certainly does not pass through the permanent forms of lower ones. What is common in a higher group of animals is always sooner developed in their embryos than what is special; out of that which is most general arises that which is less general, until that which is most special appears. Each embryo of a given type of animals, instead of passing through other definite types, becomes on the contrary more and more unlike them. An embryo of a higher type is, therefore, never identical with another animal type, but only with an embryo.

Thus far do the statements of von Baer extend.[1] It is evident from this, that he has clearly perceived the limitation of the different modes of embryonic development within the respective branches of the animal kingdom, but it is equally certain that his assertions are too general to furnish a key for the comparison of the successive changes which the different types undergo within their respective limits, and that he is still vaguely under the impression, that the development corresponds in its individualization to the degrees of complication of structure.

[1] The account which Huxley gives of Baer's views, (see Baden Powell's Essays, Appendix 7, p. 495,) is incorrect. Baer did not "demonstrate that the classification of Cuvier was, in the main, simply the expression of the fact, that there are certain common *plans of development* in the animal kingdom," etc., for Cuvier recognized these plans in the *structure* of the animals, before Baer traced their development, and Baer himself protests against an identification of his views with those of Cuvier. (Baer's Entwick., p. 7.) Nor has Baer demonstrated the "doctrine of the unity of organization of all animals," and placed it "upon a footing as secure as the law of gravitation," and arrived at "the grandest law," that, up to a certain point, the development "*followed a plan common to all animals.*" On the contrary, Baer admits four distinct types of animals, and four modes of development. He only adds: "It is barely possible that in their first beginning all animals are alike." Huxley must also have overlooked Cuvier's introduction to the "Règne Animal," (2d edit., vol. 1, p. 48, quoted verbatim above, p. 193,) when he stated that Cuvier "did not attempt to discover upon what plans animals are constructed, but to ascertain in what manner the facts of animal organizations could be thrown into the fewest possible propositions." On the contrary, Cuvier's special object, for many years, has been to point out these plans, and to show that they are characterized by peculiar structures, while Baer's merit consists in having discovered four *modes of development*, which coincide with the branches of the animal kingdom, in which Cuvier recognized four different *plans of structure*. Huxley is equally mistaken when he says that Cuvier adopted the nervous system "as the base of his great divisions."

This could hardly be otherwise, as long as the different categories of the structure of animals had not been clearly distinguished.[1]

CLASSIFICATION OF K. E. VON BAER.

In conformity with his embryological investigations, K. E. von Baer proposes the following classification.

I. Peripheric Type. (RADIATA.) Evolutio radiata. The development proceeds from a centre, producing identical parts in a radiating order.

II. Massive Type. (MOLLUSCA.) Evolutio contorta. The development produces identical parts curved around a conical or other space.

III. Longitudinal Type. (ARTICULATA.) Evolutio gemina. The development produces identical parts arising on both sides of an axis and closing up along a line opposite the axis.

IV. Doubly Symmetrical Type. (VERTEBRATA.) Evolutio bigemina. The development produces identical parts arising on both sides of an axis, growing upwards and downwards, and shutting up along two lines, so that the inner layer of the germ is inclosed below and the upper layer above. The embryos of these animals have a dorsal cord, dorsal plates, and ventral plates, a nervous tube and branchial fissures.

1°. They acquire branchial fringes;

a. But no genuine lungs are developed.

α. The skeleton is not ossified. Cartilagineous Fishes.

β. The skeleton is ossified. Fishes proper.

b. Lungs are formed. Amphibia.

α. The branchial fringes remain. Sirens.

β. The branchial fringes disappear. Urodela and Anura.

2°. They acquire an allantois, but

a. Have no umbilical cord;

α. Nor wings and air sacs. Reptiles.

β. But wings and air sacs. Birds.

b. Have an umbilical cord. Mammalia.

α. Which disappears early;

1°. Without connection with the mother. Monotremata.

2°. After a short connection with the mother. Marsupialia.

β. Which is longer persistent;

1°. The yolk sac continues to grow for a long time.

The allantois grows little. Rodentia.

The allantois grows moderately. Insectivora.

The allantois grows much. Carnivora.

2°. The yolk sac increases slightly.

The allantois grows little. Umbilical cord very long. Monkeys and Man.

The allantois continues to grow for a long time. Placenta in simple masses. Ruminants.

The allantois continues to grow for a long time. Placenta spreading. Pachyderms and Cetacea.

[1] Compare Chap. II., Sect. 1 to 9.

CLASSIFICATION OF VAN BENEDEN.

Van Beneden has also proposed a classification based upon Embryology, which was first sketched in his paper upon the Embryology of Bryozoa: Recherches sur l'anatomie, la physiologie et l'embryogénie des Bryozoaires, Bruxelles, 1845, 4to., and afterwards extended in his Comparative Anatomy: Anatomie comparée, Bruxelles, (without date, but probably from the year 1855,) 1 vol. 12mo.

I. HYPOCOTYLEDONES or HYPOVITELLIANS. (Vertebrata.) The vitellus enters the body from the ventral side.

- CL. 1. Mammalia. (Primates, Cheiroptera, Insectivora, Rodentia, Carnivora, Edentata, Proboscidea, Ungulata, Sirenoidea, Cetacea.)
- CL. 2. Birds. (Psittaceæ, Rapaces, Passeres, Columbæ, Gallinæ, Struthiones, Grallæ, Palmipedes.)
- CL. 3. Reptiles. (Crocodili, Chelonii, Ophidii, Saurii, Pterodactyli, Simosauri, Plesiosauri, Ichthyosauri.)
- CL. 4. Batrachians. (Labyrinthodontes, Peromelia, Anura, Urodela, Lepidosirenia.)
- CL. 5. Fishes. (Plagiostomi, Ganoidei, Teleostei, Cyclostomi, Leptocardii.)

II. EPICOTYLEDONES or EPIVITELLIANS. (Articulata.) The vitellus enters the body from the dorsal side.

- CL. 6. Insects. (Coleoptera, Nevroptera, Strepsiptera, Hymenoptera, Lepidoptera, Diptera, Orthoptera, Hemiptera, Thysanura, Parasita.)
- CL. 7. Myriapodes. (Diplopoda, Chilopoda.)
- CL. 8. Arachnides. (Scorpiones, Araneæ, Acari, Tardigrada.)
- CL. 9. Crustacea. (Decapoda, Stomapoda, Amphipoda, Isopoda, Læmodipoda, Phyllopoda, Lophyropoda, Xiphosura, Siphonostoma, Myzostoma, and Cirripedia.)

III. ALLOCOTYLEDONES or ALLOVITELLIANS. (Mollusco-Radiaria.) The vitellus enters the body neither from the ventral nor from the dorsal side.

- CL. 10. Mollusca. Including Cephalopoda, Gasteropoda, Pœcilopoda, and Brachiopoda. (Acephala, Tunicata, and Bryozoa.)
- CL. 11. Worms. (Malacopoda, Annelides, Siponculides, Nemertini, Nematodes, Acanthocephali, Scoleides, Hirudinei.)
- CL. 12. Echinoderms. (Holothuriæ, Echinides, Stellerides, Crinoides, Trematodes, Cestodes, Rotiferi, Planariæ.)
- CL. 13. Polyps. Including Tunicata, Bryozoa, Anthozoa, Alcyonaria, and Medusæ, as orders. (Ctenophoræ, Siphonophoræ, Discophoræ, Hydroids, Anthophoridæ.)
- CL. 14. Rhizopods. Only the genera mentioned.
- CL. 15. Infusoria. Only genera and families mentioned.

Van Beneden thinks the classification of Linnæus truer to nature than either that of Cuvier or of de Blainville, as the class of Worms of the Swedish naturalist corresponds to his Allocotyledones, that of Insects to his Hypocotyledones, and the four classes of Pisces, Amphibia, Aves, and Mammalia to his Hypocotyledones. He compares his primary divisions to the Dicotyledones, Monocotyledones, and Acotyledones of the vegetable kingdom. But he overlooks that the Cephalopods

are not Allocotyledones, and that any group of animals which unites Mollusks, Worms, and Radiates in one great mass cannot be founded upon correct principles. As to his classes, I can only say that if there are natural classes among animals, there never was a combination of animals proposed since Linnæus, less likely to answer to a philosophical idea of what a class may be, than that which unites Tunicata with Polyps and Acalephs. In his latest work, Van Beneden has introduced in this classification many important improvements and additions. Among the additions, the indication of the orders, which are introduced in brackets in the diagram above, deserve to be particularly noticed. These changes relate chiefly to the Mollusks and Polyps; the Tunicata and Bryozoa being removed from the Polyps to the Mollusks. The Acalephs and Polypi, however, are still considered as forming together one single class.

The comparison, instituted by Van Beneden between his classification of the animal kingdom and that of the plants most generally adopted now, leads me to call again attention to the necessity of carefully scrutinizing anew the vegetable kingdom, with the view of ascertaining how far the results I have arrived at concerning the value of the different kinds of natural groups existing among animals,[1] apply also to the plants. It would certainly be premature to assume, that because the branches of the animal kingdom are founded upon different plans of structure, the vegetable kingdom must necessarily be built also upon different plans. There are probably not so many different modes of development among plants as among animals; unless the reproduction by spores, by naked polyembryonic seeds, by angiospermous monocotyledonous seeds, and by angiospermous dicotylodonous seeds, connected with the structural differences exhibited by the Acotyledones, Gymnospermes, Monocotyledones, and Dicotyledones, be considered as amounting to an indication of different plans of structure. But even then these differences would not be so marked as those which distinguish the four branches of the animal kingdom. The limitation of classes and orders, which presents comparatively little difficulty in the animal kingdom, is least advanced among plants, whilst botanists have thus far been much more accurate than zoölogists in characterizing families. This is, no doubt, chiefly owing to the peculiarities of the two organic kingdoms.

It must be further remarked, that in the classification of Van Beneden the animals united under the name of Allocotyledones are built upon such entirely different plans of structure, that their combination should of itself satisfy any unprejudiced observer that any principle which unites them in that way cannot be true to nature.

[1] See Chap. II., p. 137 to 178.

DIAGRAM OF THE DEVELOPMENT OF ANIMALS BY KÖLLIKER.

KÖLLIKER, (A.,) in his Entwickelungsgeschichte der Cephalopoden, Zurich, 1844, 1 vol. 4to., p. 175, has submitted the following diagram of the development of the animal kingdom.

A. The embryo arises from a primitive part. (Evolutio ex una parte.)
  1°. It grows in two directions, with bilateral symmetry. (Evolutio bigemina.)
    a. The dorsal plates close up. Vertebrata.
    b. The dorsal plates remain open and are transformed into limbs. Articulata.
  2°. It grows uniformly in every direction. (Evolutio radiata.) And
    a. Incloses the embryonal vesicle entirely.
      α. This takes place very early. Gasteropoda and Acephala.
      β. This takes place late. (Temporary vitelline sac.) Limax.
    b. Contracts above the embryonal vesicle. (Genuine vitelline sac.) Cephalopoda.

A. The whole body of the embryo arises simultaneously. (Evolutio ex omnibus partibus.)
  1°. It grows in the direction of its transverse axis,
    a. With its hind body. Radiata. (Echinoderms.)
    b. With the fore body, and
      α. The hind body does not grow. Acalephs.
      β. The hind body grows longitudinally. Polypi.
  2°. It grows in the direction of its longitudinal axis. Worms.

I have already shown how unnatural a zoölogical system must be which is based upon a distinction between total or partial segmentation of the yolk.[1] No more can a diagram of the development of animals, which adopts this difference as fundamental, be true to nature, even though it is based upon real facts. We ought never to single out isolated features, by which animals may be united or separated, as most anatomists do; our aim should rather be to ascertain their general relations, as Cuvier and K. E. von Baer have so beautifully shown.[2] I think also, that the homology of the limbs of Articulata and the dorsal plates of Vertebrata is more than questionable. The distinction, introduced between Polyps and Acalephs and these and the other Radiates, is not any better founded. It seems also quite inappropriate to call the development of Mollusks, evolutio radiata, especially after Baer had designated, under that same name, the mode of formation of the branch of Radiates, for which it is far better adapted.

[1] Chap. III., Sect. 1, p. 171.

[2] The principles of classification advocated by Baer are so clearly expressed by him, that I cannot resist the temptation of quoting some passages from the paper already mentioned above, p. 224, especially now, when I feel called upon to oppose the views of one of his most distinguished colleagues. "Vor allen Dingen muss man, um eine richtige Einsicht in die gegenseitige Verwandtschaft der Thiere zu erlangen, die verschiedenen Organisationstypen von den verschiedenen Stufen der Ausbildung stets unterscheiden. Dass man diesen Unterschied gewöhnlich nicht im Auge behalten hat, scheint uns zu den sonderbarsten Zusammenstellungen geführt zu haben." Beiträge, etc., Acta Nova, vol. 13, p. 739.

CLASSIFICATION OF VOGT.

Contrast between the Embryo and the Yolk.

I. VERTEBRATA. Yolk ventral.

CL. 1. Mammalia. 1°. Aplacentaria; *Ord.* Monotremata, Marsupialia. 2°. Placentaria. *Ser.* 1. *Ord.* Cetacea, Pachydermata, Solidungula, Ruminantia, and Edentata; *S.* 2. Pinnipedia, Carnivora; *S.* 3. Insectivora, Volitantia, Glires, Quadrumana, Bimana.

CL. 2. Aves. *Ser.* 1. Insessores; *Ord.* Columbæ, Oscines, Clamatores, Scansores, Raptatores; *Ser.* 2. Autophagi; *Ord.* Natatores, Grallatores, Gallinacea, Cursores.

CL. 3. Reptilia. *Ord.* Ophidia, Sauria, Pterodactylia, Hydrosauria, and Chelonia.

CL. 4. Amphibia. *Ord.* Lepidota, Apoda, Caudata, Anura.

CL. 5. Pisces. *Ord.* Leptocardia, Cyclostomata, Selachia, Ganoidea, Teleostia.

II. ARTICULATA. Yolk dorsal.

CL. 6. Insecta. *Subcl.* 1. Ametabola; *Ord.* Aptera. *Subcl.* 2. Hemimetabola; *Ord.* Hemiptera and Orthoptera. *Subcl.* 3. Holometabola; *Ord.* Diptera, Lepidoptera, Strepsiptera, Nevroptera, Coleoptera, Hymenoptera.

CL. 7. Myriapoda. Only divided into families.

CL. 8. Arachnida. *Series* 1. Pycnogonida and Tardigrada; *Ord.* Acarina, Araneida. *Series* 2. With three families.

CL. 9. Crustacea. *Subcl.* 1. Entomostraca; *Ord.* Cirripedia, Parasita, Copepoda, Phyllopoda, Trilobita, Ostracoda. *Subcl.* 2. Xiphosura. *Subcl.* 3. Podophthalma; *Ord.* Stomapoda, Decapoda. *Subcl.* 4. Edriophthalma; *Ord.* Læmipoda, Amphipoda, Isopoda.

Transformation of the whole Yolk into the Embryo.

III. CEPHALOPODA. Yolk cephalic.

CL. 10. Cephalopoda. *Ord.* Tetrabranchiata and Dibranchiata.

IV. MOLLUSCA. Irregular disposition of organs.

CL. 11. Cephalophora. *Subcl.* 1. Pteropoda. *Subcl.* 2. Heteropoda. *Subcl.* 3. Gasteropoda; *Ord.* Branchiata and Pulmonata. — Chitonida.

CL. 12. Acephala. *Subcl.* 1. Brachiopoda; *Ord.* Rudista, Brachiopoda. *Subcl.* 2. Lamellibranchia; *Ord.* Pleurochoncha, Orthoconcha, Inclusa.

CL. 13. Tunicata. *Ord.* Ascidiæ, Biphora.
CL. 14. Ctenophora. Only subdivided into families. } Molluscoidea.
CL. 15. Bryozoa. *Ord.* Stelmatopoda, Lophopoda.

V. VERMES. Organs bilateral.

CL. 16. Annelida. *Ord.* Hirudinea, Gephyrea, Scoleina, Tubicola, Errantia.

CL. 17. Rotatoria. *Ord.* Sessilia, Natantia.

CL. 18. Platyelmia. 1°. *Ord.* Cestoidea, Trematoda. 2°. *Ord.* Planarida, Nemertina.

CL. 19. Nematelmia. *Ord.* Gregarinea, Acanthocephala, Gordiacei, Nematoidei.

VI. RADIATA. Organs radiate.

CL. 20. Echinodermata. *Ord.* Crinoidea, Stellerida, Echinida, Holothurida.

CL. 21. Siphonophora. Only subdivided into families.

CL. 22. Hydromedusæ. Not clearly subdivided into orders.

CL. 23. Polypi. *Ord.* Hexactinia, Pentactinia, Octactinia.

No Egg.

VII. PROTOZOA.

CL. 24. Infusoria. *Ord.* Astoma and Stomatoda.

CL. 25. Rhizopoda. *Ord.* Monosomatia and Polythalamia.

The classification of Vogt (Zoologische Briefe, q. a., p. 180) presents several new features, one of which is particularly objectionable. I mean the separation of the Cephalopoda from the other Mollusks, as a distinct primary division of the animal kingdom. Having adopted the fundamental distinction introduced by Kölliker between the animals in which the embryo is developed from the whole yolk, and those in which it arises from a distinct part of it, Vogt was no doubt led to this step in consequence of his interesting investigations upon Actæon, in which he found a relation of the embryo to the yolk differing greatly from that observed by Kölliker in Cephalopods. But as I have already shown above, this cannot any more justify their separation, as branches, than the total segmentation of the yolk of Mammalia could justify the separation of the latter from the other Vertebrates. Had the distinction made by Vogt, between Cephalopods and the other Mollusks, the value he assigns to it, Limax should also be separated from the other Gasteropods. The assertion that Protozoa produce no eggs, deserves no special consideration after what has already been said in the preceding sections respecting the animals themselves. As to the transfer of the Ctenophora to the type of Mollusks, it can in no way be maintained.

Before closing this sketch of the systems of Zoölogy, I cannot forego the opportunity of adding one general remark. If we remember how completely independent the investigations of K. E. von Baer were from those of Cuvier, how different the point of view was from which they treated their subject, the one considering chiefly the mode of development of animals, while the other looked mainly to their structure; if we further consider how closely the general results at which they have arrived agree throughout, it is impossible not to be deeply impressed with confidence in the opinion they both advocate, that the animal kingdom exhibits four primary divisions, the representatives of which are organized upon four different plans of structure, and grow up according to four different modes of development. This confidence is further increased when we perceive that the new primary groups which have been proposed since are neither characterized by such different plans, nor developed according to such different modes of development, but exhibit simply minor differences. It is, indeed, a very unfortunate tendency, which prevails now almost universally among naturalists, with reference to all kinds of groups, of whatever value they may be, from the branches down to the species, to separate at once from one another any types which exhibit marked differences, without even inquiring first whether these differences are of a kind that justifies such separations. In our systems, the quantitative element of differentiation prevails too exclusively over the qualitative. If such distinctions are introduced under well-sounding names, they are almost certain to be adopted; as if science gained any thing by concealing a difficulty under a Latin

or Greek name, or was advanced by the additional burden of a new nomenclature. Another objectionable practice, prevailing quite as extensively also, consists in the change of names, or the modification of the extent and meaning of old ones, without the addition of new information or of new views. If this practice is not abandoned, it will necessarily end in making Natural History a mere matter of nomenclature, instead of fostering its higher philosophical character. Nowhere is this abuse of a useless multiplication of names so keenly felt as in the nomenclature of the fruits of plants, which exhibits neither insight into vegetable morphology, nor even accurate observation of the material facts.

May we not return to the methods of such men as Cuvier and Baer, who were never ashamed of expressing their doubts in difficult cases, and were always ready to call the attention of other observers to questionable points, instead of covering up the deficiency of their information by high-sounding words!

In this rapid review of the history of Zoölogy, I have omitted several classifications, such as those of Kaup and Van der Hoeven, which might have afforded an opportunity for other remarks, but I have already extended this digression far enough to show how the standards I have proposed in my second chapter may assist us in testing the value of the different kinds of groups generally adopted in our classifications, and this was from the beginning my principal object in this inquiry. The next step should now be to apply these standards also to the minor divisions of the animal kingdom, down to the genera and species, and to do this for every class singly, with special reference to the works of monographers. But this is such an herculean task, that it can only be accomplished by the combined efforts of all naturalists, during many years to come.

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